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BIOSTRATIGRAPHY OF THE GLENOGLE FORMATION (ORDOVICIAN) NEAR GLENOGLE, BRITISH COLUMBIA

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

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by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Biostratigraphy of the Glenogle Formation (Ordovician) near Glenogle, British Columbia", submitted by Murray Lloyd Larson, B.A. (Saskatchewan), in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The type section of the Glenogle Formation (Ordovician) is incomplete due to the faulting and poor exposure, nevertheless, enough section is exposed in the Kicking Horse River Valley, British Columbia, to piece together a composite section.

The base of the Glenogle shales is gradational with the underlying McKay Formation and the contact with the overlying Wonah quartzite is not exposed.

Twenty-four genera and forty species of graptolites of Early and Middle Ordovician Age (Arenig to Caradoc) with a distinct Pacific aspect are recorded from the type area. The Deepkill-Normanskill zonation is abandoned and the Texas zonation proposed by Berry is provisionally adopted. In ascending order, the zonation consists of, Didymograptus protobifidus, Isograptus caduceus, Paraglossograptus etheridgei, ?Diplograptus decoratus, Glyptograptus cf. teretiusculus and Nemagraptus gracilis. Two modifications of the Texas zonal sequence are made: (1) The Glenogle zone of Didymograptus protobifidus is equivalent to the zones of Didymograptus bifidus and Didymograptus protobifidus of Texas; (2) The Australian zone of Diplograptus decoratus is tentatively recognized in the Glenogle area. This zone is equivalent to the upper part of the Paraglossograptus etheridgei Zone of Texas. The zones recognized at Glenogle are remarkably similar to those of the Yukon, Texas and Australia but are different from those of Britain. The thickness of the zones cannot be ascertained because exposures containing the faunas occur almost exclusively as limited outcrops.

New forms recorded for the first time in Canada include Tetragraptus bigsbyi var. latus, Glossograptus hincksi mut. bispinatus, Glossograptus ciliatus var. douglasi, Parabrograptus tribrachiatus, ?Didymograptus robustus, and Brachiograptus aff. etaformis.

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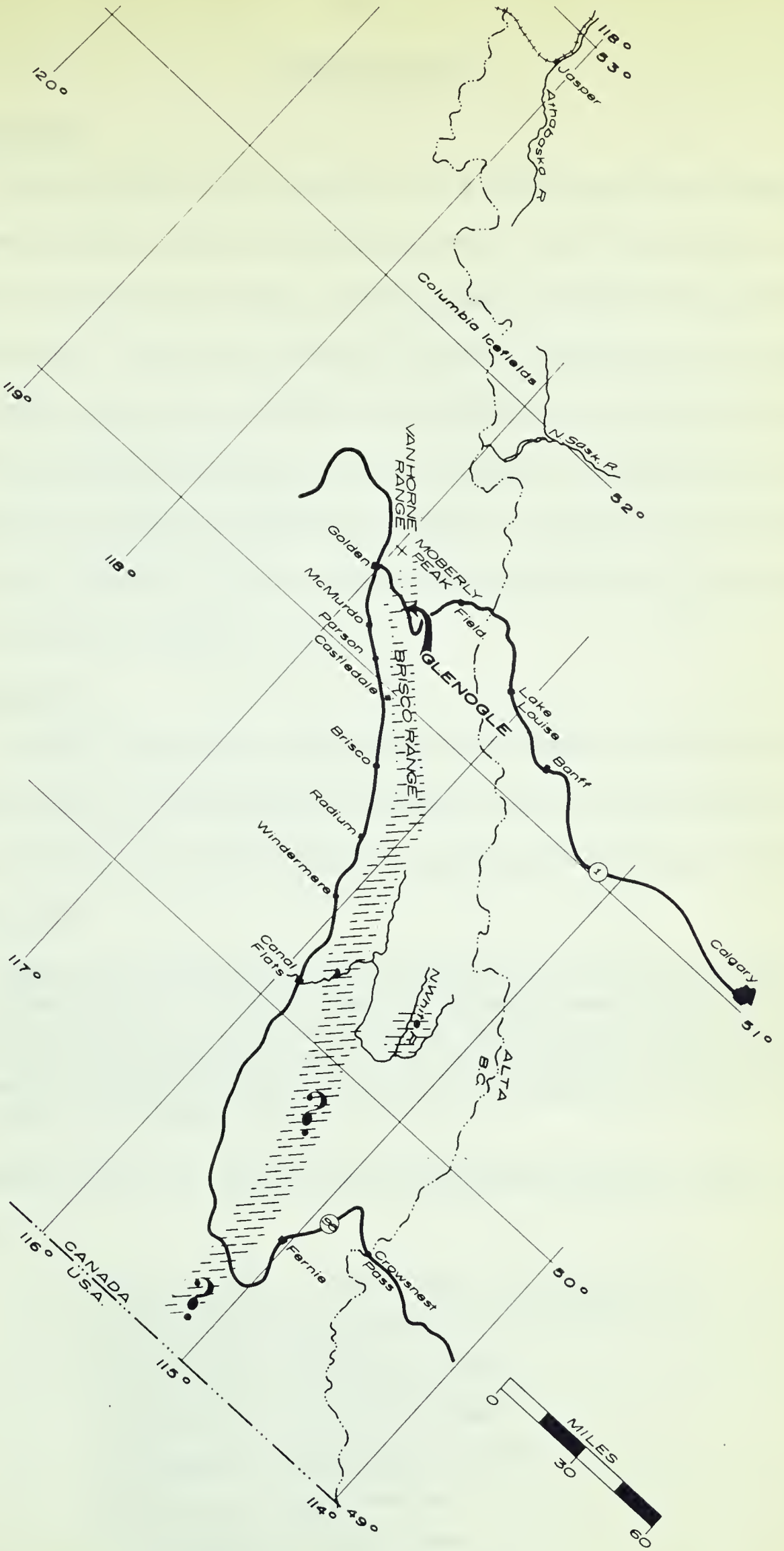

MAP I. SHOWING GRAPTOLITE SHALE BELT IN S.E. BRITISH COLUMBIA.

INTRODUCTION

Location of area

The area under study is located in the Kicking Horse River valley 3.2 to 8 miles east of Golden, British Columbia (see Maps 1 and 2) and is easily accessible from the Trans-Canada Highway and the Canadian Pacific Railway which transect the area. The mountain ranges to the south and north are very rugged with the highest peaks rising to 8500 feet from 3200 feet in the Kicking Horse River. Only the highest peaks and ridges are treeless, the valleys are narrow and V-shaped and access~~ibility~~ to these areas is difficult. Hope Creek and Cable Creek are new names that have been given to two creeks that flow southward to join the Kicking Horse River.

Historical Review

In 1886, McConnell, working along the Canadian Pacific Railway between the Foothills and the Columbia River, described a section of black graptolitic shales which he called the "Graptolitic Shales". Concerning the thickness and distribution he stated (p. 22)

> "They have a thickness of about 1500 feet in the Beaverfoot Range, south of Palliser, but thin out considerably going north towards the Wapta canyon (Kicking Horse Canyon).....They are found on both sides of the Beaverfoot range, and good and easily accessible sections, close to the railway, may be found in the bed of a small stream which joins the Wapta (Kicking Horse) River about halfway between Palliser and Golden City".

The graptolites collected at this point were identified by Lapworth (1887, p. 320) as follows:

Didymograptus sp. nov. allied to D. euodus Lapw.
Glossograptus ciliatus Emmons
Glossograptus spinulosus (J. Hall)
Cryptograptus tricornis (Carruthers)
Diplograptus angustifolius (J. Hall)
Diplograptus rugosus Emmons
Climacograptus coelatus Lapw.
Phyllograptus ?spp.
Lasiograptus ?spp.

McConnell thought this fauna correlated with that of the Trenton-Utica of the United States and that it was similar to the Llandeilo of Britain.

In the early part of the 20th century Ruedemann (1904, p. 490) established a zonal scheme for the graptolites in New York State which later became the standard to which the graptolites of British Columbia were referred. This scheme is shown below:

Lower Dicellograptus Zone	Normanskill
Zone with Diplograptus dentatus and Cryptograptus antennarius	Third Deepkill (Bed 6 and 7)
Zone with Didymograptus bifidus and Phyllograptus anna	Second Deepkill (Bed 3 and 5)
Zone with Tetragraptus .. .. Subz. a. Goniograptus b. Clonograptus	First Deepkill (Bed 1 and 2)

In the Field map area, Allan (1914 p. 100) referred to these black shales as the "Graptolitic Shales", comprised of black, carbonaceous and brown fissile shales at the top underlain by grey shales with another band of black shales near the base. The uppermost beds were very fossiliferous. He stated:

"The best section is exposed along the mainline of the Canadian Pacific Railway in the lower Kicking Horse Canyon at Glenogle. In Glenogle Creek and in the small creek to the west, this formation was found to be 1700 feet thick.... The best exposure of the fossiliferous shale is in a small creek a few hundred yards west of Glenogle Station".

Allan republished McConnell's (1886) faunal list.

Burling (1922, p. 452-461) formally named these graptolitic shales the "Glenogle Shales" and wrote:

"The fact that we have now secured data as to the relations of the graptolite shales to the overlying formation, together with paleontological evidence as to the age of the beds immediately below, leads me to the conclusion that they should be named; and since they were first found at Glenogle....it would seem appropriate that they be called the Glenogle Shales".

Burling cited the first creek west of Glenogle Station and the adjacent rock-cutting in particular as the type-section and noted that the formation thinned from 1700 feet to 700 feet in the summits of the range ten miles south of Glenogle. Burling con-

tinued:

"The lower (Canadian) portion of the formation can be studied in the first creek east of Glenogle and the overlying beds (Chazyan) can be studied in the high summits to the south".

Burling came to the conclusion that there was no unconformity either above or below the Glenogle.

Walcott (1924, p. 33) published a list of fossils collected by Burling from the railway-cutting and identified by Ruedemann:

Loganograptus logani mut. tardus Rued.
Didymograptus serratulus J. Hall
_____ sp. nov. aff. D. forcipiformis Rued.
_____ sp. nov. aff. D. filiformis Tullberg
_____ sagitticaulis Gurley
_____ spinosus Rued.
Cryptograptus tricornis (Carruthers)
Climacograptus antiquus Lapw.
Diplograptus cf. D. teretiusculus Hisinger
Lasiograptus sp. nov.
Glossograptus horridus Rued.

Ruedemann (in Walcott 1924, p. 33) commented on this assemblage as follows:

"This fauna is a new association of forms indicating a horizon between the Deepkill and Normanskill Shales....The faunas published by Lapworth from the Kicking Horse Canyon contain the most common forms of the present fauna....and therefore belongs to the same general horizon as the one collected by Burling".

A little below Tunnel 31.08 (3.6 miles east of Golden) on the Canadian Pacific Railway the following fossils were identified by Ruedemann (in Walcott 1924, p. 34)

Clonograptus sp. nov. cf. tenellus (Linnarsson)
Loganograptus logani J. Hall
Tetragraptus bigsbyi J. Hall
_____ sp. nov. aff. fruticosus J. Hall
_____ (Etagr.) cf. lentus Rued.
Phyllograptus cf. typus J. Hall
Didymograptus cf. extensus J. Hall

Didymograptus bifidus J. Hall
_____ sp. nov. aff. gracilis Tornquist

Ruedemann considered the age of this fauna to be decidedly older than the one Lapworth published from Kicking Horse Canyon and belonging to the Didymograptus bifidus horizon (Sensu Ruedemann not Elles).

One hundred miles farther south (Walcott 1924, p. 34) named the black graptolitic shales in Sinclair Canyon the Sinclair Formation because its relationship with the Glenogle had not been determined. Ruedemann correlated the fauna from here with his Bed 7 of the Deepkill section (top of the Deepkill Shale). (See Appen. part A, 1).

Clark (1926, p. 136) examined the Glenogle Shales in the vicinity of Glenogle and concluded that Burling had lumped the faunas from the railway-cutting and the small creek to the west. The following assemblage is cited from the first creek west of ~~one of~~ the railway-cutting and represents the Normanskill fauna.

Didymograptus serratulus (J. Hall)
_____ sagitticaulis Gurley
_____ euodus Lapw.
Cryptograptus tricornis (Carruthers)
Lasiograptus sp.
Diplograptus augustifolius J. Hall
_____ teretiusculus Hisinger
Glossograptus ciliatus mut. horridus Rued.
_____ ciliatus Emmons.

The railway-cutting yielded only Deepkill forms.

Bryograptus cf. kjerulfi Lapw.
Loganograptus logani J. Hall
_____ logani mut. tardus Rued.
Tetragraptus quadribrachiatus J. Hall
Didymograptus euodus Lapw.
_____ spinosus Rued.
_____ gracilis Tornquist
_____ nicholsoni Lapw.
_____ affinis Tornquist

Didymograptus filiformis Rued.
Isograptus forcipiformis Rued.
_____ caduceus mut. nanus Rued.
Glossograptus inutilis (J. Hall)
_____ ciliatus Emmons
Climacograptus antennarius (J. Hall)
Retiograptus tentaculatus (J. Hall)
Lasiograptus sp.
Trigonograptus ensiformis (J. Hall)
?Diplograptus dentatus (Brongniart)

Clark considered that this fauna, with the exception of Loganograptus logani and Bryograptus kjerulfi, was characteristic of the upper part of the Deepkill series (Zone of Diplograptus dentatus and Climacograptus antennarius).

A very thick section of Glenogle was studied by Walker (1926) in the Windermere area of British Columbia where a complete section of Glenogle, near the head of Windermere Creek, measured 2162 feet in thickness. The lower part of the formation is chiefly black shale with interbeds of hard mudstone and bluish limestone. The upper part grades from a sandy shale to a thin-bedded argillaceous sandstone.

The succession of faunas in this section was visualized by Ruedemann in the following manner.

Top
956 to 1627 ft. - Last Deepkill Zone (3rd Deepkill) of New York and Quebec

780 to 946 ft. - Didymograptus bifidus Zone (2nd Deepkill) of North America

87 to 946 ft. - Tetragraptus Zone (1st Deepkill)

0 to 87 ft. - ?Clonograptus Zone (1st Deepkill) of the Point Levis section.

Base

North-west of this locality on the north fork of Windermere Creek, Walker (1926) found the Glenogle to be 200 feet thick and stated:

"The fauna seems to indicate a horizon about the boundary between the Didymograptus walcottorum Zone and the third Deepkill". (Appen. part A, 3).

Another section east of Tegart Mountain was also examined by Walker and was found to be 450 feet thick. The zonation is tabulated below. (Appen. part A, 3).

5 to 10 ft. below top of shale - Third Deepkill Zone

10 to 15 ft. below top of shale - Third Deepkill Zone

40 to 50 ft. below top of shale - Third Deepkill Zone, low

Base of shale - Glenogle Zone of Didymograptus walcottorum
(= I. caduceus Zone of modern workers)

Walker correlated the Glenogle shales in the Windermere section with Walcott's Sinclair Formation in Sinclair Canyon. This led Walcott in 1926 to say:

"The more recent studies of Mr. J. F. Walker in the Windermere area prove conclusively that the Glenogle graptolite fauna extends throughout the upper arenaceous beds and the lower black shales and argillaceous layers at the head of Windermere Creek that correspond to the Sinclair Formation....This makes the term Sinclair a synonym of Glenogle".

Evans (1932), while mapping the Brisco-Dogtooth area, traced the outcrop of the Glenogle shales from the Windermere area northward into the Van Horne Range, north of Glenogle Station. Evans indicated that the Normanskill Zone is represented at Pinnacle and Beard Creeks. A new record of forms typical of a Normanskill fauna, (Nemagraptus gracilis, N. exilis var. linearis, Retiograptus geinitzianus) from a collection made by Ami in 1891 from the "Glenogle Slate quarries"* was listed in Evans (1932) (Appen. part A, 4).

No further work was done on the Glenogle until 1954 when Leech mapped the Canal Flats area. He found the Glenogle to be 450 feet on the west flank of White Knight Mountain (Appen. part A, 5) and on the northern watershed of Moscow Creek, 1000 to 1100 feet thick (Appen. part A, 6). The graptolite

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* the exact location of the Glenogle Slate quarries is not known as no quarries exist in the area. However, it is believed this means the railway-cutting at Glenogle.

assemblages from these two sections indicated a late Early Ordovician (Canadian) to early Middle Ordovician (Deepkill)Age; no definite Normanskill fauna appeared to be present.

In the same year, Henderson (1954) examined a 120-foot section of Glenogle two miles south of Pedley Pass in southeast British Columbia. (Appen. part A, 7) Here the Glenogle consists of black shales and argillaceous sandstones and few beds of blue-grey limestones. The fauna collected from this section is representative of the Third Deepkill Zone (Zone of Diplograptus dentatus and Climacograptus antennarius).

In the appendix (Part A) a complete faunal list from the areas other than Glenogle is given.

Purpose of Investigation

The early workers collected from this area and the forms were identified mainly by Ruedemann (1924, 1926, 1932, 1947), who assigned the faunas a position in the Deepkill-Normanskill succession of New York State. Nearly four decades passed before investigations by Berry (1960) in the Marathon region of Texas and Jackson (1964) in the Canadian Cordillera, showed that Ruedemann's zonal scheme was unsatisfactory for western North America. Certain assemblages not recognized in New York are present both in the Marathon region and western Canada. Berry (1962) after careful study and recollecting of the Deepkill-Normanskill strata found that the Early to Middle Ordovician succession of New York was incomplete.

The main purpose of this thesis was to collect, identify and zone the graptolites of the Glenogle Formation at the type area in the light of these recent definitive works. The type locality would then provide a framework of reference for the graptolitic shales of south-eastern British Columbia.

The Diplograptus decoratus Zone, the Glyptograptus cf. teretiusculus

Zone and the Nemagraptus gracilis Zone represent the youngest zones in the Glenogle and to date are found only at the type section. These zones have not been found in the Windermere Creek section which is the most complete section of the Glenogle known and some explanation is needed to account for their presence at Glenogle and their absence at Windermere Creek.

As a result of structural complications and poor exposures at the type locality, previous collections were lumped. Discrete collecting was done to avoid this pitfall and to record more accurately, both spacially and stratigraphically, the zones present.

Method of Investigation

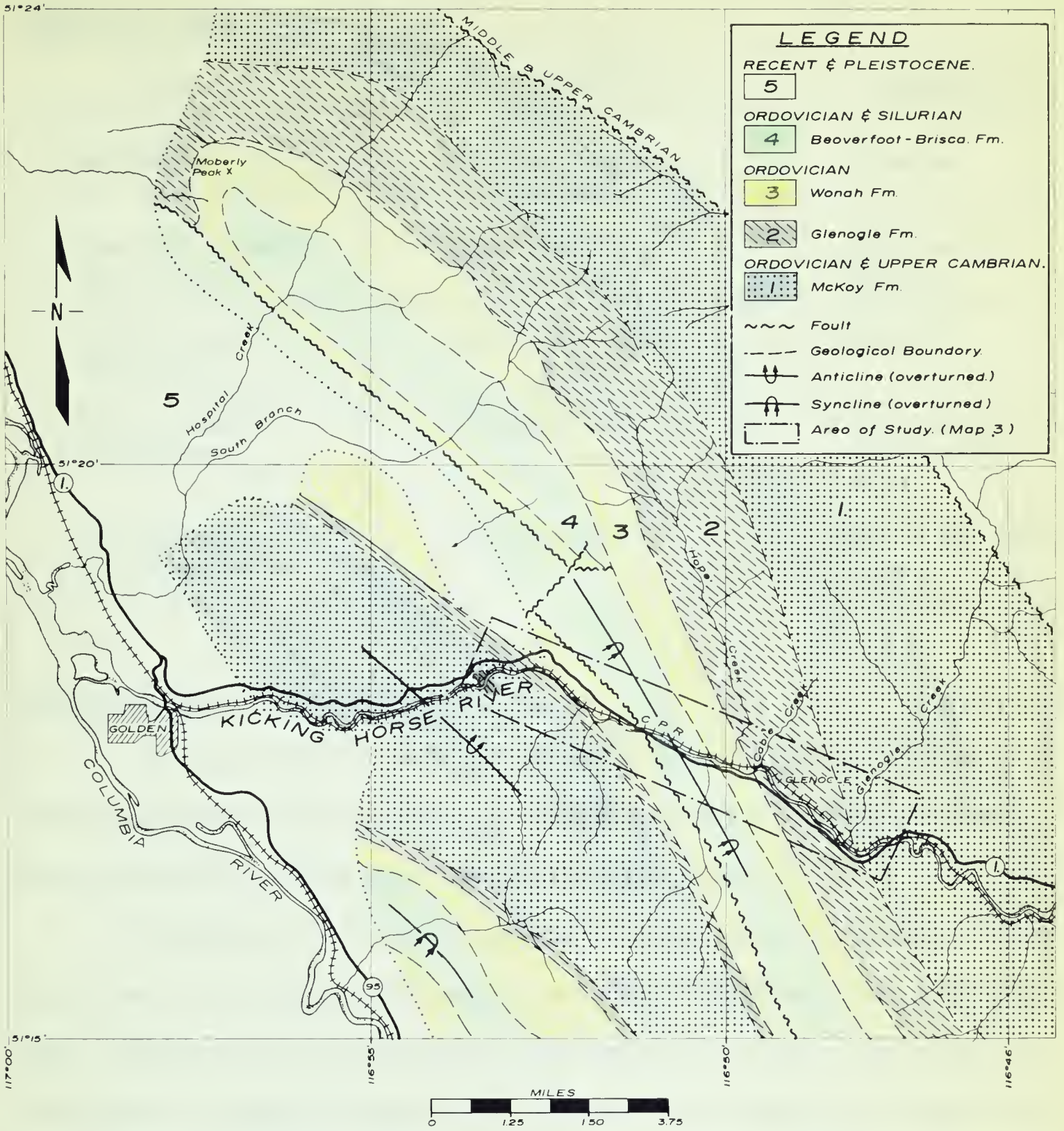
The graptolites from each location were identified with the aid of a binocular microscope. Measurements and descriptions were noted, comparison made to references and the identification made.

Graptolites, because of their very nature, pose a problem of photography. Three methods are listed and discussed below.

1. Photograph of graptolite in liquid (chlorothene or water) with an electronic flash held at side.
2. Photograph of dry graptolite using a Honeywell Ring Electronic Flash.
3. Photograph of graptolite in liquid (as in 1) using an electronic ring flash.

Method 1 produces favourable results, however, a reflection often clouds the photograph because of the angle the electronic flash is held. Methods 2 and 3 are the most satisfactory. Depending on the contrast of the graptolites and the background either method may be used. As a general rule if the contrast can be seen with the naked eye the ring flash dry method produces most satisfactory results. Camera used was a Nikon F equipped with a micronikor lens, 55 mm., F 3.5.

The identifications were made from collections of Dr. D. E. Jackson and the writer and these collections are located at the Geology Department, University of Alberta.



MAP 2. GENERAL GEOLOGY of VAN HORNE & BRISCO RANGES
(after Evans 1932)

STRATIGRAPHY

General Geology

AGE	FORMATION	LITHOLOGY
Middle Devonian	Harrogate Formation	Limestone
	Unconformity	
Late Ordovician to Early Silurian	Beaverfoot-Brisco Formation	Limestone and dolomite
Middle to Late Ordovician	Wonah Formation	Quartzite
Early to Middle Ordovician	Glenogle Formation	Black shale, limy shale and silty shale
Late Cambrian to Early Ordovician	McKay Formation	Shales and limestones

McKay Formation (Evans 1932)

The type section of the McKay is near John McKay Creek, a tributary of Sinclair Creek near Radium. McKay strata are variable but consist for the most part of alternations of blue-grey limestones and grey shales.

The thickness at the type section is 4000 feet and on Jubilee and Steamboat Mountains, in the same area but west of the Trench, the McKay is only 2000 feet thick. Farther south in the Windermere map-area McKay strata occur extensively in the eastern, central and western fault blocks*. In the eastern fault block they are the oldest rocks exposed and measure 3500 feet in thickness. In the central fault block the formation attains its maximum thickness of 4000 feet. Rapid and irregular variations in the thickness occur in the western fault block ranging from 0 to 2000 feet. The Canal Flats area again shows the east-west variation in thickness. In the eastern (Moscow Creek) structural division, 4500 feet of McKay is

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* These fault blocks were originally delineated by Henderson (1954)

exposed whereas in the western (White Swan) structural division there is 2,500 feet of strata.

Physical evidence exists, at the type area (near loc. 4), that the McKay Formation is conformably overlain by the Glenogle Formation (cf. Patterson 1961, p. 1365, who postulated an unconformity between the Glenogle Formation and the McKay Formation on theoretical grounds). West of the Trench the McKay is overstepped by the Beaverfoot-Brisco Formation. In the Windermere region the McKay is overlain conformably by Glenogle in the eastern and central fault blocks while in the western fault block it is overlain with apparent conformity by Beaverfoot-Brisco. The same situation exists in the Canal Flats map-area.

Faunal evidence (Evans, 1932) indicates eight faunal zones are represented in the type section consisting in ascending order of the zones of (1) Dikelocephalus, (2) Symphysurina, (3) Kainella, (4) Ozarkispira, (5) Xenostegium, (6) Diplograptus ?dentatus, (7) Megalaspis and (8) Ampyx. The First zone is of late Cambrian Age; zones 2 to 5 are Early Ordovician and zones 5 to 8 are Middle Ordovician. Likewise, Kobayashi (1955, p.372) indicated that the faunal transition from Late Cambrian to Early Ordovician was relatively gradual and that the Cambrian-Ordovician boundary lies within the McKay. Evans (1932) thought the upper four zones of the McKay in the western part of the Brisco-Van Horne Ranges were the same age as the Glenogle Formation in the eastern part of the same area. He based this assumption on the presence of Diplograptus ?dentatus in a shaly bed of the McKay at the type section. This would indicate contemporaneous limestone deposition in the west and shale in the east.

Glenogle Formation (Burling, 1922)

The type Glenogle occurs as an incomplete section in the vicinity of Glenogle Station, on the mainline of the Canadian Pacific Railway, where it consists of a sequence of black shales, arenaceous shales, and limy shales.

In the type area no accurate thickness can be established because of structural complications which took place during the Laramide Orogeny. Allan (1914) measured 1,700 feet near Glenogle; Evans (1932) indicated that the Glenogle thinned from 1,600 feet in the central and eastern parts of the Brisco Range to zero feet on the western slope of the same range 3 to 4 miles west; Jackson (pers. comm. 1964) measured +1,200 feet in the vicinity of Glenogle and the writer measured 700 feet at the formation's northernmost occurrence on Moberly Peak a few miles northwest. In the Windermere map-area the thickness is again variable. In the eastern fault block at Windermere Creek this unit is 2,150 feet thinning northward to 1,650 feet on Mount Sinclair and southward to 300 feet on Nappe Mountain a few miles distant. On the eastern side of the central fault block the Glenogle is 1,000 feet thick at the north end of the map-area and 300 feet at the south end. On the western side of the same fault block the Glenogle is less than 600 feet at the north end and missing ~~completely~~ at the south end. The Glenogle in the Canal Flats map-area is 1,000 feet in the eastern (Moscow Creek) fault block and thins to 400 feet, 4 miles south-west, in the western (White Swan) fault block. Farther west across the Trench it is also absent. The evidence is well documented that the Glenogle thins from east to west. The question arises as to whether this is depositional thinning, erosion or a combination of both. The Glenogle-Wonah boundary between Golden and Canal Flats appears to be concordant and sharp. In places, particularly near Golden, and in the western occurrences it is gradational.

In the graptolite shale belt the Wonah appears to rest at different places on different zones of the Glenogle. Two explanations are proposed to explain this phenomenon:

1. The G. cf. teretiusculus and N. gracilis Zones present at Glenogle have been either eroded or not deposited in the Windermere Creek section. This is hard

to prove because nowhere has there been recorded definite evidence for erosion or an unconformity although Walker (1926, p. 31) states "The Wonah quartzite rests on what appears to be an erosion surface of the Glenogle Shales". The beds at the contact are conformable and the boundary between the overlying Wonah is in many localities gradational, however, in the eastern sections it is sharp.

2. The lower part of the Wonah at Windermere Creek is the time equivalent of the upper part (two uppermost zones) of the Glenogle Formation at Glenogle. This situation cannot be proven because the Wonah contains no definitive fossils nor can interfingering be seen that would indicate a facies change on this scale.

Needless to say, further examination of the Glenogle-Wonah contact over a wide areal extent is necessary before a definite conclusion can be drawn.

The faunal zones present in the Glenogle range from the lowest zone of Didymograptus protobifidus (2nd Deepkill zone of Ruedemann) through Isograptus caduceus; Paraglossograptus etheridgei (3rd Deepkill of Ruedemann); ?Diplograptus decoratus; Glyptograptus cf. teretiusculus and Nemagraptus gracilis (Normanskill of Ruedemann). The age of the Glenogle therefore is Arenig to Early Caradoc.

Wonah Formation (Walcott, 1924)

The type section of the Wonah is on the southwest slope of Wonah Ridge above Sinclair Canyon near Radium and typically consists of a medium-grained, well-cemented, well-sorted, thick-bedded, clean quartzite. It is generally pinkish or white and oscillation marks and cross-bedding are common.

In the western part of the Brisco Range, near Radium, the formation is 30 feet thick; a few miles east, still within the Brisco Range it is 1,200 feet thick. Northward the quartzite becomes much thicker; 1,000 feet east of Castledale, 1,500 feet at Horse Creek and 1,000 feet at its northernmost occurrence on Moberly Peak, just northeast of Golden. West of the Trench the Wonah is absent. In the Windermere map-area the Wonah shows a thinning from east to

west throughout the area. In the east fault block it is 350 feet thick, 100 feet on the east side of the central fault block and absent on the western side of the same fault block. Westward thinning occurs again in the Canal Flats map-area where the Wonah is 300 feet in the eastern fault block and 35 feet in the western block.

The boundary with the overlying Beaverfoot-Brisco is sharp in the eastern areas and gradational in the western portions.

The fossils in the Wonah are conspicuous by their absence and only a few crinoid fragments and orthids are found. The overlying beds carry a Richmond fauna, thus it seems reasonable to assume the age of the Wonah to be at least in part, Caradoc and possibly Richmond.

Beaverfoot-Brisco Formation (Burling,1922; Walcott,1924)

The Beaverfoot was first named by Burling (1922) and assigned a Richmond age. Walcott (1924) subsequently discovered that the upper part of Burling's Beaverfoot contained Silurian fossils and he created the name Brisco for the Silurian portion. In the field there is no distinctive change in lithology and this sequence is treated as one map unit consisting of thick-to thin-bedded crystalline limestones and dolomites of which the latter is the more abundant. The color of the fresh surface varies from place to place but the dull, powdery coating, white to light salmon-grey of the weathered surface is distinctive.

The type section of the Beaverfoot is at the crest of the Beaverfoot Range south of Palliser and the type Brisco is on the upper southwest slope of Sinclair Mountain, south of Sinclair Pass.

The thickness in the Brisco-Van Horne Ranges near Golden is 1,882 feet at Harrogate and this decreases, apparently due to erosion,to 200 feet west of the Trench on Horsethief Creek. In the Windermere area the most complete section occurs in the central fault block but it also occurs in all three fault blocks.

In the Brisco-Van Horne Ranges the contact with the overlying Harrogate

is structurally conformable although a considerable break in time is represented. In the Windermere area the Beaverfoot-Brisco is overlain by the ?Devonian Burnais Formation (Henderson 1954, p. 25) which seems to occur only in this area and is absent to the north in the Brisco-Van Horne Ranges. The lithology of the Burnais consists of well-bedded and finely laminated gypsum. Nowhere has a complete section been measured but the thickness is estimated at 700 to 1,300 feet. The contacts with the overlying and underlying formations are not visible and no fossils are found.

The Beaverfoot portion contains a Richmond fauna with such forms as Receptaculites, Calopoecia, Favistella alveolata Wilson, Streptelasma trilobatum Whiteaves and Rhynchotrema cf. capax. (Conrad). A Silurian fauna consisting of Monograptus spp., Virgiana, Halysites, Syringopora, Favosites, Atrypina and Stropheodonta occurs in the Brisco portion.

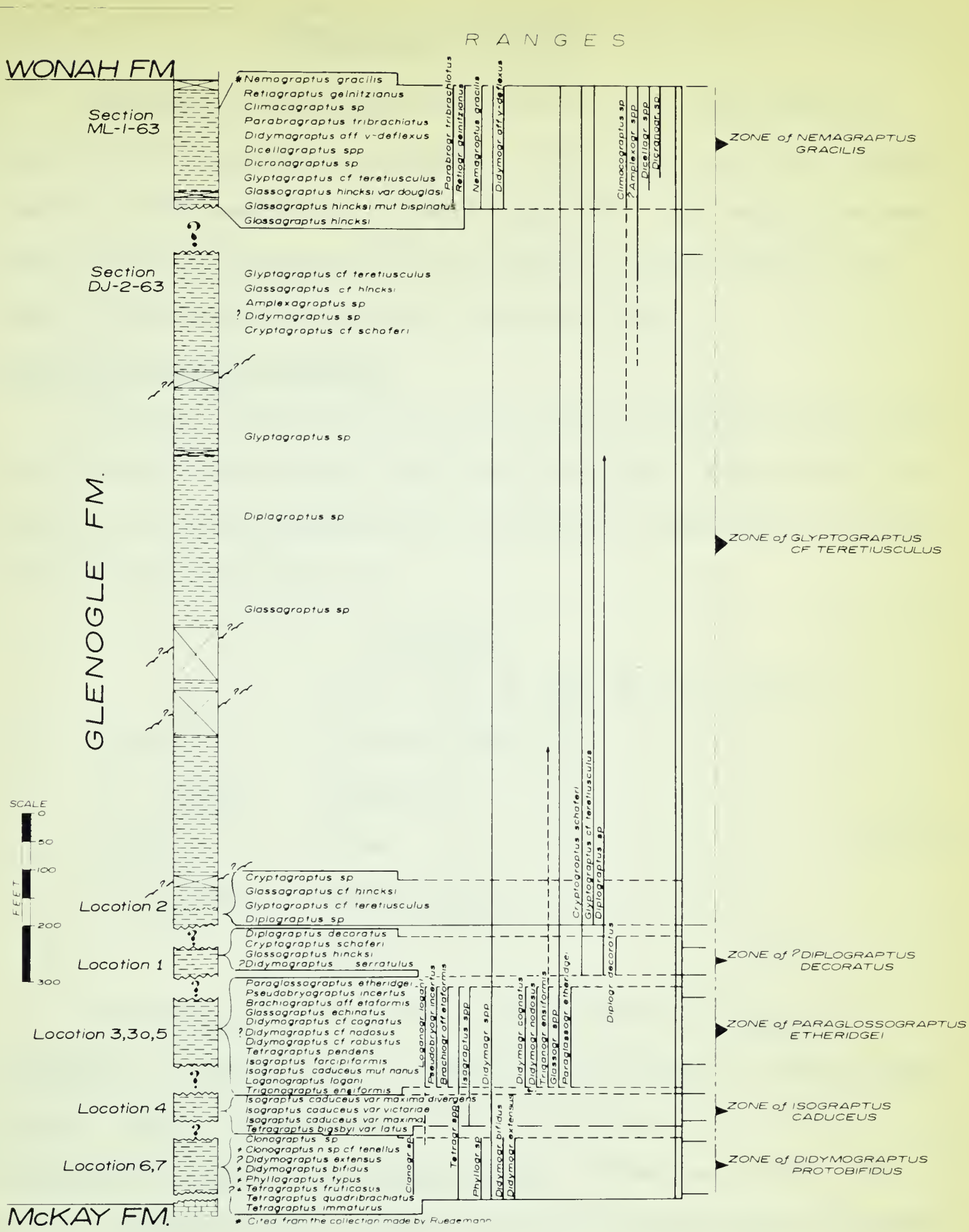

FIG. 1. COMPOSITE SECTION SHOWING A SCHEMATIC REPRESENTATION OF THE ZONES & ASSEMBLAGES PRESENT IN THE TYPE AREA OF THE GLENOGLE FMN. WITH THICKNESSES APPROXIMATELY TO SCALE. RANGE OF SOME OF THE MORE COMMON FORMS IN THIS AREA IS ALSO INDICATED.

DISCUSSION OF ZONES

Graptolites in the Glenogle Formation at the type locality permit the zonation of the formation into 6 zones (Fig. 1). The scheme of zonation is modelled after the well-documented Texas succession (Berry 1960). Some modifications were made which will be discussed below but the zones that the writer believes to be present in the Glenogle area agree well with those of Texas.

Zone of Didymograptus protobifidus

Walcott's location 21K (near Tunnel 31.08, 3.6 miles east of Golden B.C., on the Canadian Pacific Railway) was revisited by the writer. The collecting was poor because of extreme weathering of the Glenogle but in spite of this a collection of 71 specimens was made (Fig. 2).

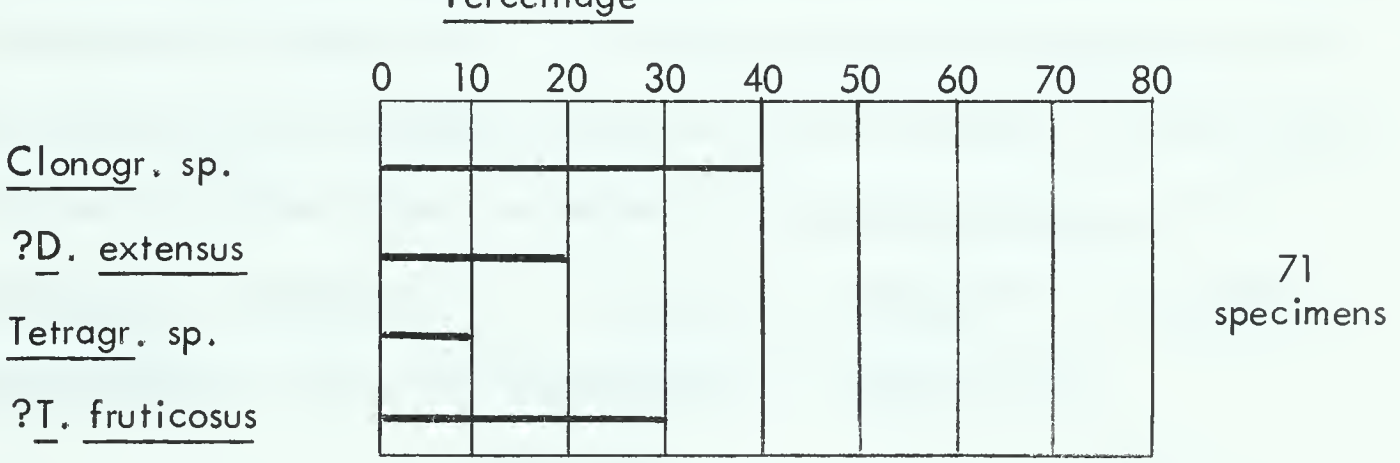

Fig. 2 Loc. 6

The fauna at this location (loc. 6, Map 3) consists of Clonograptus sp., Tetragraptus cf. quadribrachiatus, T. immaturus, ?T. fruticosus and ?Didymograptus extensus. Additional forms found by Walcott (in Ruedemann 1947, p. 105) are Phyllograptus cf. typus and Didymograptus bifidus. Jackson (pers. comm. 1964) found a D. bifidus-like form at locality 7 on the Trans-Canada Highway immediately north of this tunnel.

The forms present indicate a horizon lower than the Isograptus caduceus Zone and this is reflected by the large percentage of ?Clonograptus sp. and the marked absence of any isograptids or biserial forms that are present in higher zones. The

fauna collected both by the writer and Walcott contains elements that are common to the D. bifidus and D. protobifidus Zones of Texas.

In view of the difficulty that has been encountered in separating Berry's zones of D. protobifidus and D. bifidus, which lack associated index fossils that can be used in the absence of the zonal designates and since the D. bifidus Zone in the European sense is much younger, the writer tentatively follows Jackson's (1964) merger of the two aforementioned zones to form the D. protobifidus Zone. Work is in progress to evaluate the significance of broad, pendent D. bifidus-like forms such as D. canadensis Rued. and D. columbianus Rued. from this zone in S.E. British Columbia in an attempt to accurately delimit the zone(s) in question.

Zone of Isograptus caduceus

On the north bank of the Kicking Horse River, 700 yards west of the second highway bridge east of Golden, B.C., is a 20-foot outcrop of Glenogle shale which contains a well-preserved assemblage of graptolites (loc. 4 Map 3). Of the 19 specimens collected the following forms are represented: Isograptus caduceus cf. var. maximo-divergens, I. caduceus cf. var. victoriae, I. caduceus cf. var. maxima, Tetragraptus bigsbyi var. latus and Didymograptus cf. nitidus (Fig. 3).

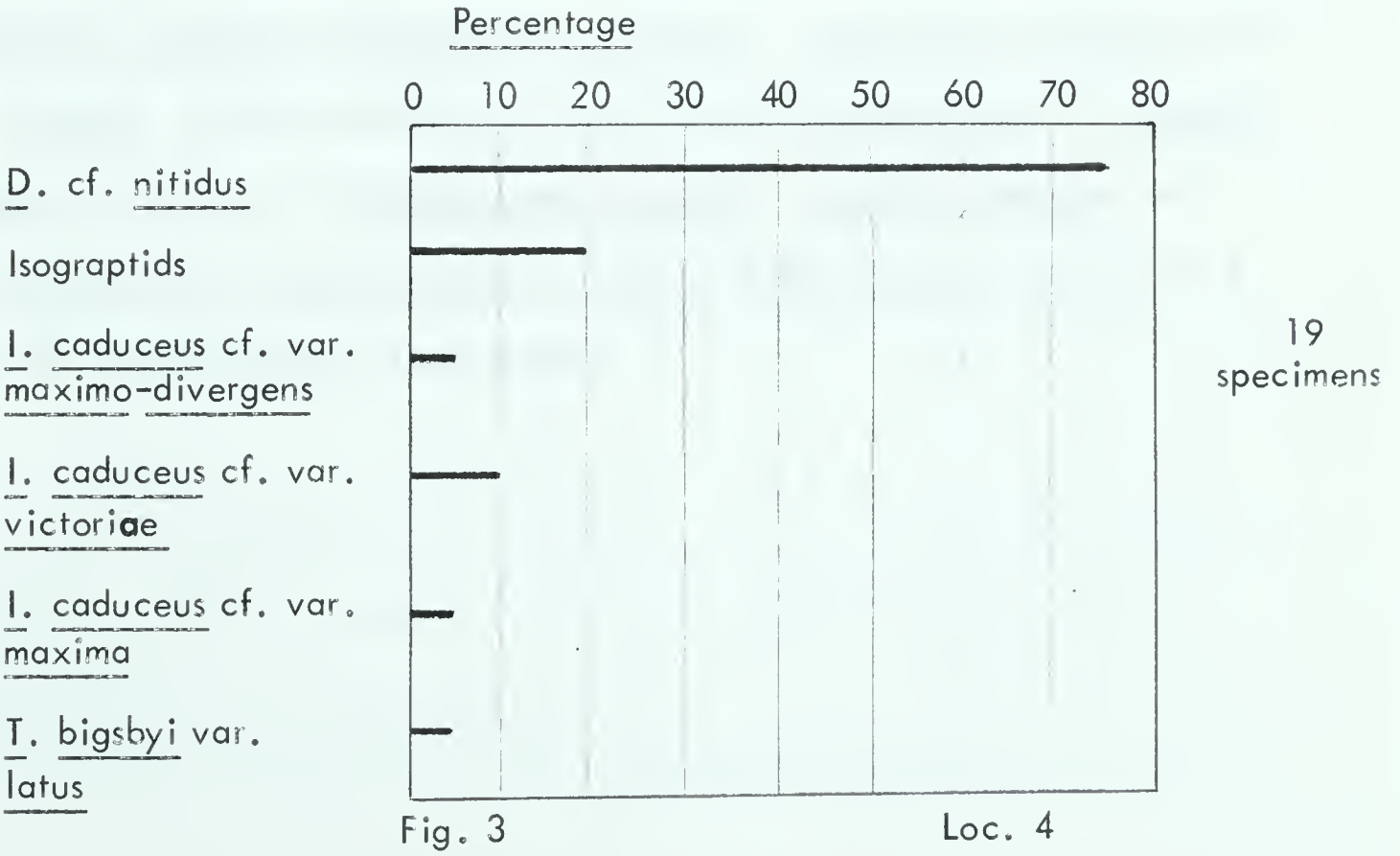

Fig. 3 Loc. 4

The fauna is assigned to the I. caduceus Zone mainly on the basis of the relatively numerous varieties of I. caduceus and the apparent lack of such biserial forms as Paraglossograptus etheridgei, Glossograptus echinatus and Cryptograptus schaferi which are characteristic of the overlying zone.

T. bigsbyi var. latus and D. cf. nitidus are not known from the caduceus Zone in Texas, however they are found in China and Britain respectively in the D. hirundo Zone; in Australia, D. nitidus is recorded from the Oncograptus and Cardiograptus Zones. Jackson (1964) has shown these zones to be, at least in part, equivalent to the I. caduceus Zone of Texas. Even though such characteristic forms as Oncograptus and Cardiograptus morsus are absent from the assemblage it is with a certain amount of assurance that designation to this zone is made.

Zone of Paraglossograptus etheridgei

The lack of variety of graptolites in the preceding zones make the richness of the P. etheridgei fauna all the more striking. This zone is recorded at locations 3 and 3a, in the cutting along the Canadian Pacific Railway a few hundred yards west of Glenogle Station and at location 5 in a road cutting on the south side of the Trans-Canada Highway. Especially significant is the presence of biserial forms such as Paraglossograptus etheridgei, Glossograptus echinatus, Trigonograptus ensiformis and Cryptogr. schaferi. Other characteristic forms include Didymograptus cf. cognatus, ?Didymograptus nodosus, cf. Glyptograptus euglyphus, Isograptus caduceus mut. nanus, I. forcipiformis, Pseudobryograptus incertus, Brachiograptus etaformis, and T. bigsbyi var. latus (See Figs. 4, 5, and 6).

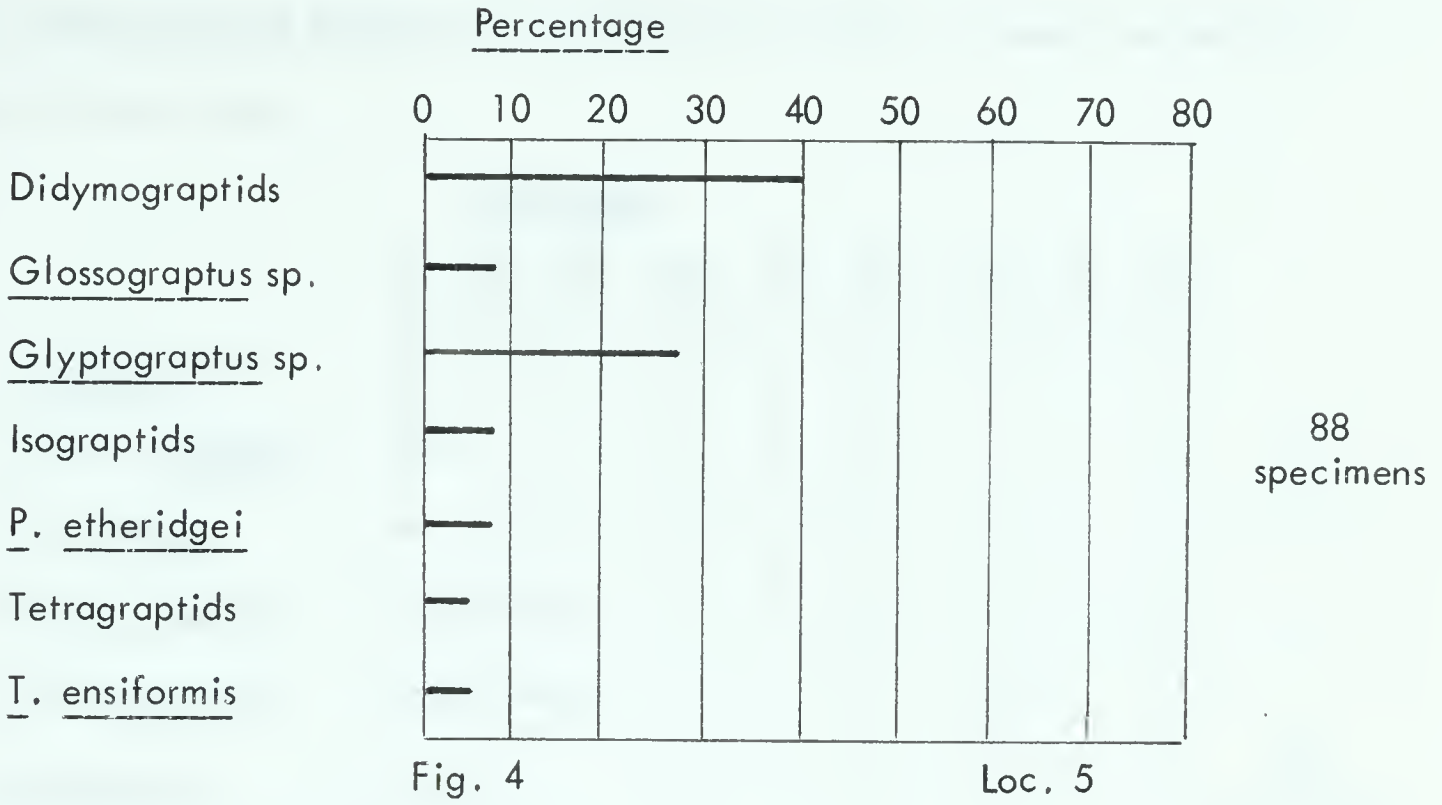

Fig. 4 Loc. 5

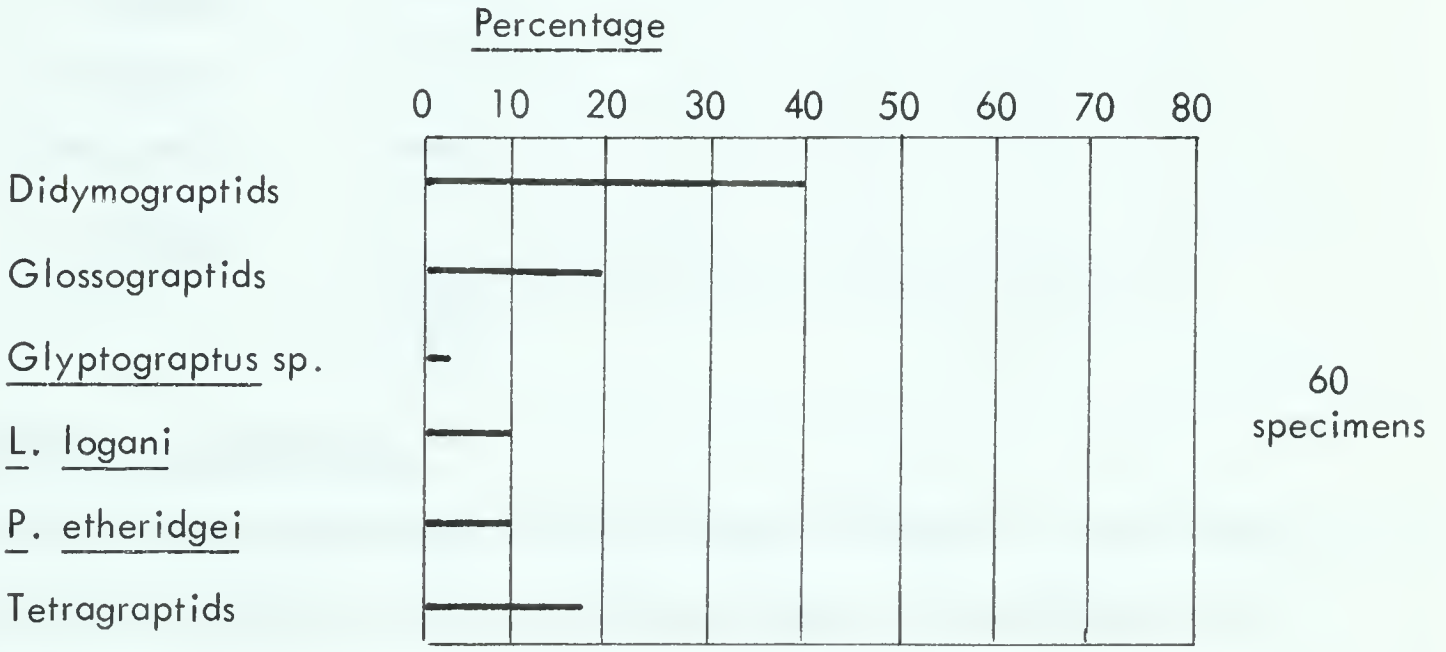

Fig. 5 Loc. 3a

This fauna represents a zone higher than that at location 4 containing a multitude of forms typical of the etheridgei Zone in Texas. The presence of the zone index fossil, Paraglossograptus etheridgei, as well as Cryptograptus schaferi, Trigonograptus ensiformis, Isograptus forcipiformis, Pseudobryograptus incertus, Loganograptus logani, and Didymograptus nodosus leaves no doubt that this zone is present and well developed in this area. Didymograptus robustus is known from

the Upper Didymograptus Shale of Sweden (Ekstrom, 1937, p. 1) and is recorded in Canada for the first time.

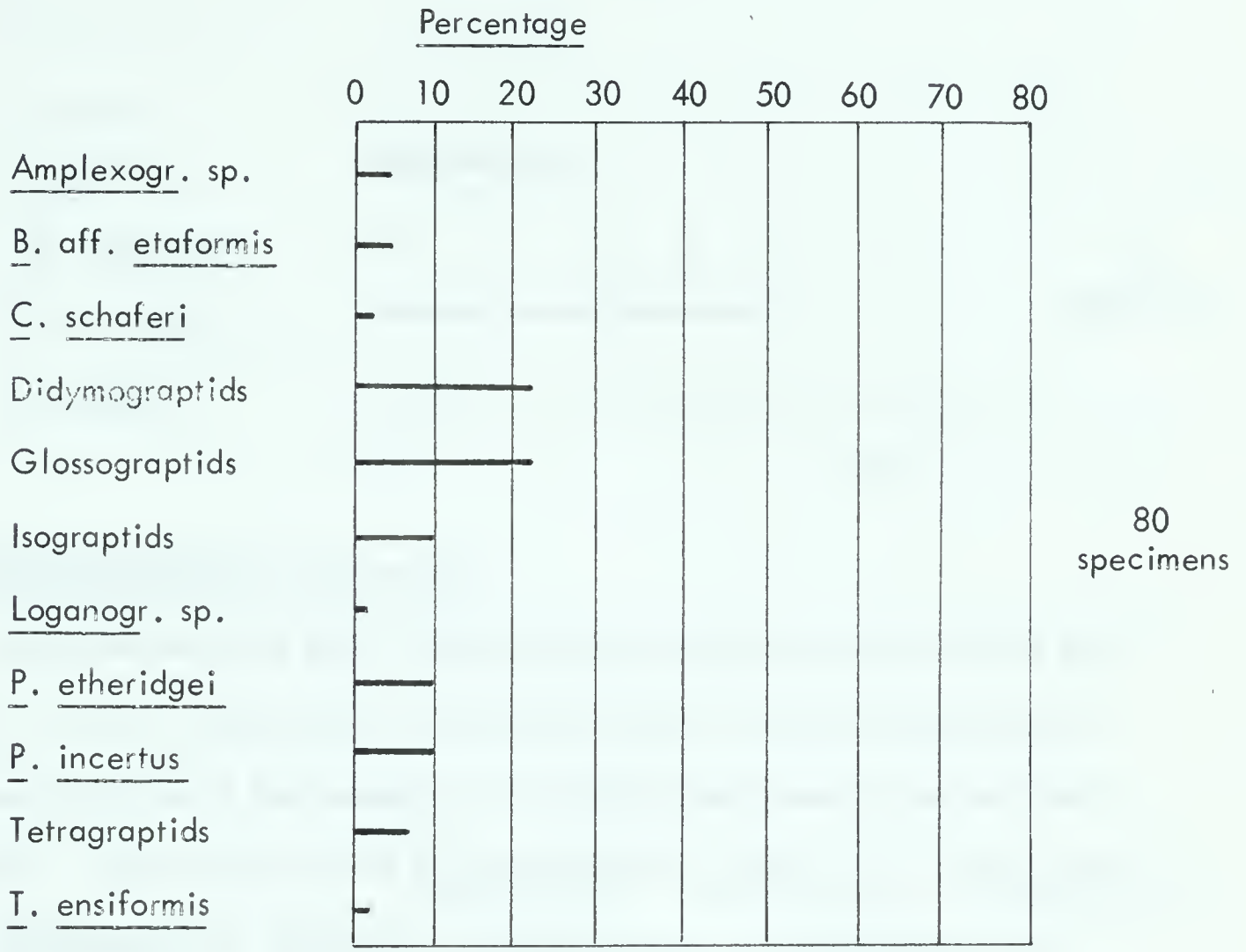

Fig. 6 Loc. 3

Zone of Diplograptus decoratus

At the western-most exposure of the railway-cutting (loc. 1) near Cable Creek, a suite of graptolites, consisting of 50 specimens, was identified and the following forms are present: Diplograptus decoratus, Cryptograptus schaferi, Glossograptus hincksi and Didymograptus serratulus (See Fig. 7).

This fauna contains elements that are very similar to those in the Australian D. decoratus Zone which is equivalent to the uppermost part of the Texas Paraglossograptus etheridgei Zone. The zone is identified on the incoming of Diplograptus decoratus and the lack of specific and generic differentia that characterize the underlying P. etheridgei Zone. If further investigations reveal this fauna elsewhere in the area this zonal assignment would be stronger. That

this fauna may be only of local occurrence is recognized and thus is tentatively designated.

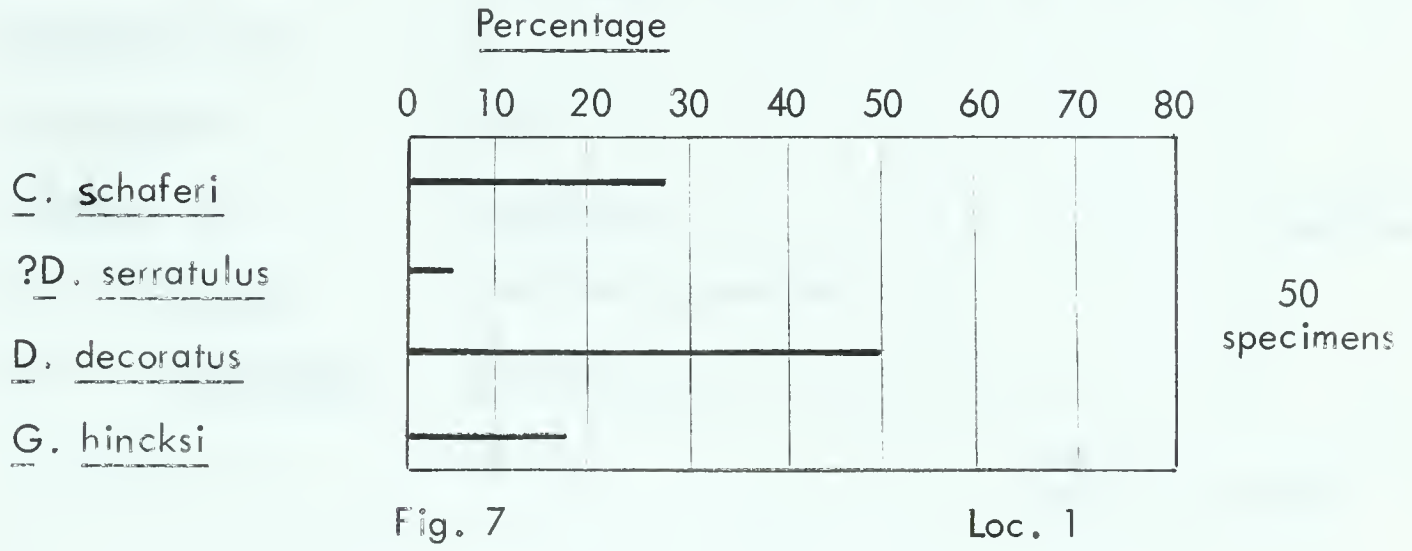

Fig. 7 Loc. 1

Zone of Glyptograptus cf. teretiusculus

Near the mouth of Cable Creek, adjacent to the Canadian Pacific Railway (loc. 2), and in Cable Creek (Section DJ-2-62), the suite of graptolites is conspicuous by virtue of the abundance of biserial forms almost to the exclusion of all others. The suite consists of Glyptograptus cf. teretiusculus, Glossograptus cf. hincksi, Diplograptus cf. decoratus, Cryptograptus sp., ?Amplexograptus sp., and ?Didymograptus sp. (see Fig. 8).

As a result of the poorly preserved nature of the specimens and a lack of a varied fauna it was with hesitation that this fauna was placed in the G. cf. teretiusculus Zone. Further investigation, however, revealed that this zone is characterized by a relative abundance of G. cf. teretiusculus and a lack of dichograptid genera. This situation exists in Texas, Britain and Australia (Table 1). G. cf. teretiusculus occurs in the zones immediately above and below the zone of this name in Texas, Britain and Australia but in all these areas genera and species characteristic of the zones above and below are not present in the zone of G. cf. teretiusculus itself. This zone is typified by its impoverished fauna, and requires careful collecting for its recognition, but because of the apparent world-wide nature of the assemblage at this horizon it is of use and as such will be adopted for the area under consideration.

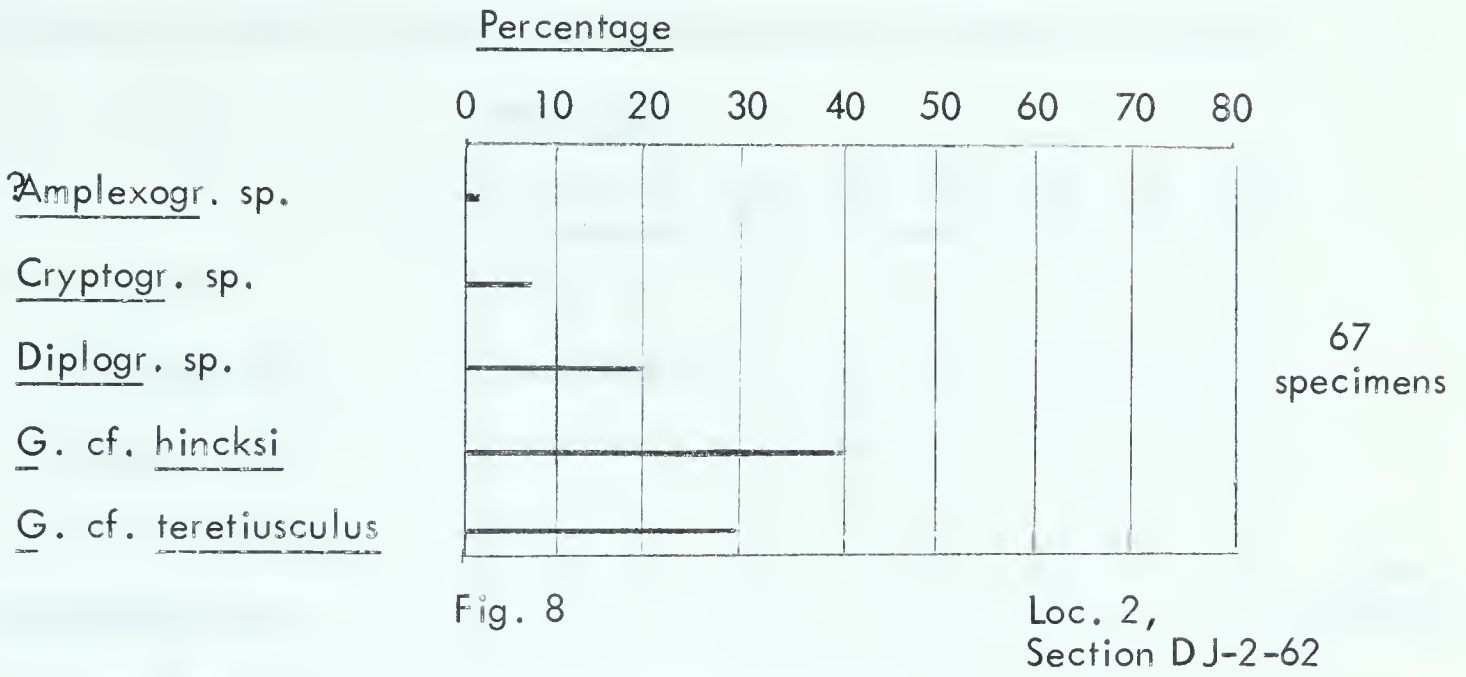

Fig. 8 Loc. 2, Section DJ-2-62

Zone of Nemagraptus gracilis

On the south bank of the Kicking Horse River and in the road-cutting along the south side of the Trans-Canada Highway opposite Glenogle Station a partial section (ML-1-63 = DJ-1-62) of 216 feet of overturned Glenogle is exposed (see Appen. part B, 2). Most of the fauna was collected from the lowest 50 feet. This section contains the youngest zone in the area.

The assemblage present is abundant and varied (see Fig. 9), particularly noticeable is the first appearance of the dicellograptids (Dicellogr. cf. sextans and cf. smithi), followed by the incoming of dicranograptids (Dicranogr. sp.). Other forms characteristic of this zone include Retiograptus geinitzianus and Glossograptus hincksi. Also present are Glyptograptus cf. teretiusculus, Didymograptus aff. v-deflexus, Glossograptus cf. whitfieldi, and Cryptograptus schaferi, Parabrograptus tribrachiatus (Jackson, pers. comm.1965), Glossogr. hincksi mut. bispinatus and Glossogr. ciliatus var. douglasi. The last-nomed two were previously known only from the upper Llanvirn of South America and are recorded here for the first time in western Canada.

The zonal index Nemagraptus gracilis was not found by the writer but it has been recorded (Ruedemann 1947, p. 103) from this area and together with the

above characteristic forms the zonal designation appears to be quite conclusive.

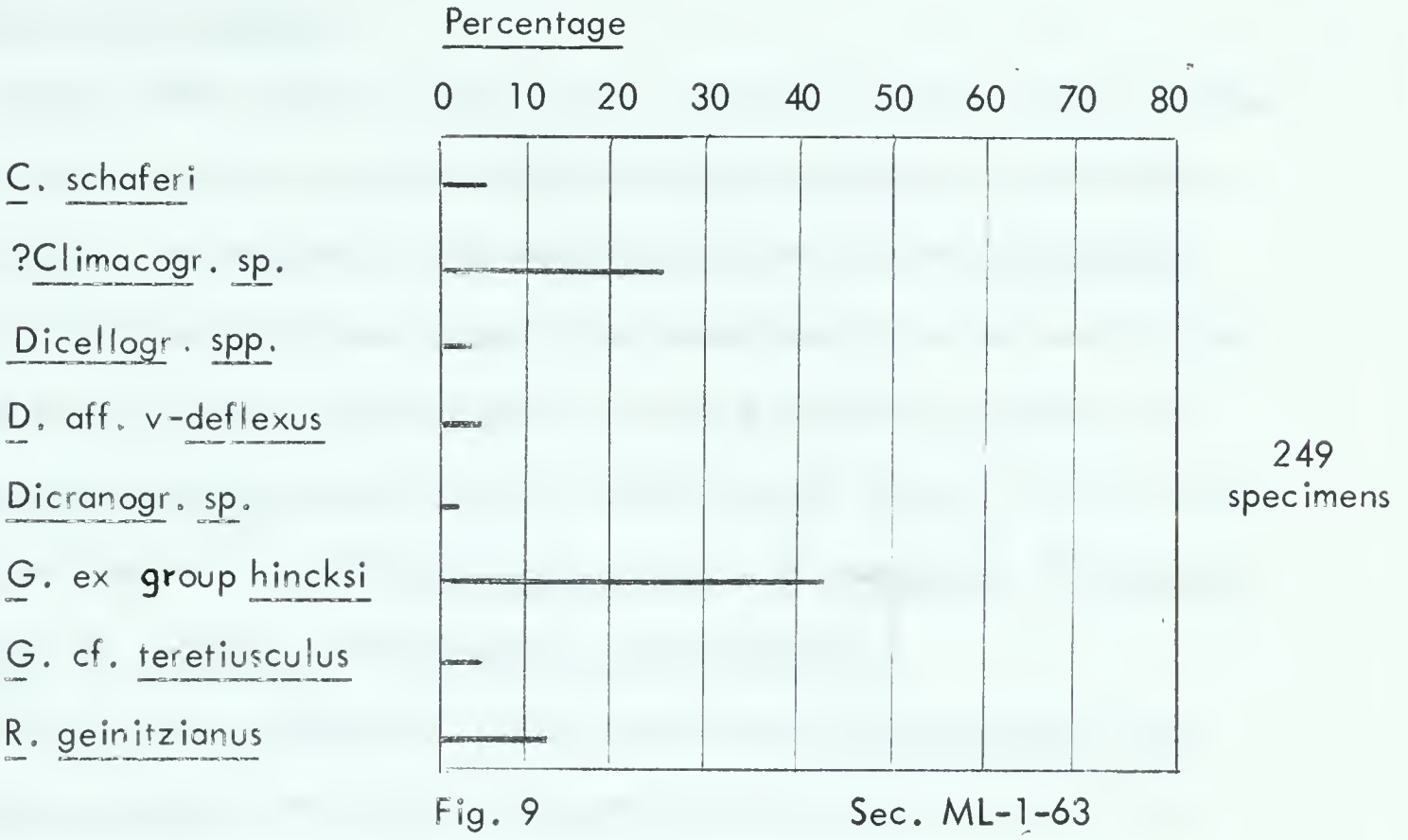

Fig. 9 Sec. ML-1-63

In the Glenogle area the zone of Nemagraptus gracilis appears to be valid in that here it characteristically represents the incoming of the dicellograptids, dicranograptids, N. gracilis and R. geinitzianus and does not appear to contain a fauna that is similar to the C. bicornis Zone of Texas, of N.E. British Columbia or of New York State where it is characterized by a greater specific variety of dicranograptids and dicellograptids along with the occurrence of Orthograptus of the truncatus variety and zonal index Climacograptus bicornis.

CORRELATION

Southeastern British Columbia

Walker (1926, Table II, p. 27) figures a distribution chart of the graptolites that he collected from the complete and thick Windermere section in southeastern British Columbia. He thought that the lowest zone present was the Clonograptus Zone (= low 1st Deepkill) but on reviewing the assemblage the writer considers that the lowest zone (0-734 ft. above the base) contains a fauna that is similar to the Didymograptus protobifidus Zone of Jackson (1964) and this thesis. This conclusion is based upon the presence of Didymograptus extensus, D. canadensis, Phyllograptus angustifolius, P. ilicifolius and Tetragraptus quadribrachiatus.

The next zone (780-946 ft. above base) contains Didymograptus nitidus and Isograptus caduceus var. maximo-divergens which are characteristic of the Isograptus caduceus Zone of Glenogle.

The youngest fauna represented at the Windermere section includes graptolites that are characteristic of the Paraglossograptus etheridgei Zone. Forms that occur in both areas are I. caduceus mut. nanus, Glossograptus echinatus and Cardiograptus crawfordi (Jackson pers. comm. 1965).

An interesting, if not perplexing, situation arises at this point in that the G. cf. teretiusculus and N. gracilis Zones that are present at Glenogle do not appear to be present in the Windermere Creek section. The D. decoratus Zone of type section if found to be valid, is also absent at Windermere. Other collections of graptolites by Leech (1954) and Henderson (1954) from the region south of Glenogle also lack graptolites that are characteristic of the upper two zones at Glenogle. This problem has been discussed previously under Stratigraphy.

Yukon

Correlation with the Yukon is facilitated by the occurrence of the most complete section of graptolite shales in North America, comprised of all the

stages and subseries of the Ordovician and Silurian of Britain. Jackson (1964) established a zonal scheme for the Road River Formation which agrees rather well with that of the Glenogle.

The Tremadocian zones in the Yukon are not present at Glenogle but the Didymograptus protobifidus Zone of the Yukon contains a fauna that is similar to the D. protobifidus Zone of Glenogle. Forms that characterize the zone in both areas include Didymograptus ex gr. bifidus, D. extensus, ?Clonograptus sp., Phyllograptus anna, P. ilicifolius and Tetragraptus quadribrachiatus.

The next zone, Isograptus caduceus, is characterized in both the Yukon and Glenogle by the incoming of the isograptids and in particular by the presence of the large varieties of I. caduceus. Originally this was included in the Glyptograptus dentatus Zone by Jackson and Lenz (1962) but subsequent investigation (Jackson,1964) indicates that the dentatus Zone can be subdivided and that a basal caduceus Zone is present.

The upper part of Jackson and Lenz's G. dentatus Zone of the Yukon is roughly equivalent to the P. etheridgei and D. decoratus Zones at Glenogle containing a fauna that includes, in both areas, Trigonograptus ensiformis, Didymograptus spinosus, Isograptus forcipiformis, Tetragraptus pendens, Cryptograptus schaferi, Pseudobryograptus sp., Isograptus caduceus mut. nanus, and Didymograptus euodus.

The Glenogle zone of Glyptograptus cf. teretiusculus appears to be the equivalent of the Yukon zone of Glyptograptus euglyphus in that both represent an impoverished fauna characterized by the abundance of biserial graptolites especially the broad glyptograptids.

The zone of Nemagraptus gracilis in both the Yukon and Glenogle is again correlative containing an assemblage with Nemagraptus gracilis, Dicellograptus sextans, Retiograptus geinitzianus and G. cf. whitfieldi in both areas.

Intercontinental Correlation

Jackson (1964) gave a concise account of the correlation of the various zones found in southeastern British Columbia with those found in Australia, Texas, Britain, and China and this topic will not be dealt with in great detail. Comments and observations that complement that study will be made where pertinent.

Table 1 depicts the relationship of the forms present at Glenogle with those found in Australia, Britain and Texas.

D. protobifidus Zone

In western Canada this zone encompasses the zones of D. protobifidus and D. balticus of Australia and the D. protobifidus and D. bifidus zones of Texas. This is mainly due to the fact that there is a lack of diagnostic forms needed to make a zonal separation in Canada.

Clonograptus does not occur as high in Texas but it is recorded from a comparable position in Australia. Didymograptus bifidus occurs only in the D. bifidus Zone of Texas while in Australia it spans the two pertinent zones of D. protobifidus and D. balticus. On the other hand Goniograptus thureaui does not occur as high in Australia as it does in Texas. Phyllograptus anna, angustifolius and ilicifolius, common forms in the protobifidus Zone at Glenogle, occur in Texas, Australia and Britain at roughly the same horizon as at Glenogle.

I. caduceus Zone

This zone is a secure tie-point in intercontinental correlation, particularly in the Pacific Province. This zone can be correlated to Britain but not with the same certainty as to Australia and Texas.

Didymograptus cf. nitidus does not occur as high in Texas but the equivalent zones of I. caduceus vars., Oncograptus and Cardiograptus of Australia contain D. nitidus. This zone and its equivalents in all the areas under discussion is marked by the incoming of the isograptids. Isograptus caduceus vars. victoriae, maxima and maximo-

divergens occur at approximately the same level in Australia, Texas and Glenogle but they are not present in Britain.

P. etheridgei Zone

Another secure correlation in the Pacific Province is the zone of P. etheridgei in Canada and Texas and its equivalents in Australia (G. austrodentatus to G. intersitus). This zone is marked in these areas by the incoming of the amplexograptids, Pseudobryograptus incertus, Brachiograptus aff. etaformis, Didymograptus nodosus and Paraglossograptus etheridgei. Didymograptus cf. robustus and Tetragraptus bigsbyi var. latus are new to Canada; the former is found in an equivalent position (D. bifidus to P. elegans Zones) in Sweden and the latter in the Amplexograptus confertus Zone in China. Tetragraptus pendens does not occur as high in Texas or Australia but it is recorded from this zone in the Yukon.

?D. decoratus Zone

The D. decoratus Zone occurs in Australia in a position equivalent with the upper part of the P. etheridgei Zone of Texas. As stated previously this zone may not have any great areal extent in western Canada and if this is found to be the situation then the fauna from this zone would be included in the P. etheridgei Zone.

G. cf. teretiusculus Zone

This zone presents a problem in correlation. In all areas, both in the Pacific Province and Britain, it is characterized by an impoverished fauna and the relative abundance of broad glyptograptids of the teretiusculus type. To correlate only on the basis of the presence of G. teretiusculus is dangerous,but it is a feature of the zone that it does not contain the multiplicity of forms that are characteristic of the zone below it and does not contain the forms that mark the next higher zone. Thus it is with a reasonable amount of assurance that an intercontinental correlation is achieved.

N. gracilis Zone

In Texas, Australia, Britain and Glenogle this zone is characterized by the first appearance of Nemagraptus, dicellograptids, dicranograptids. Retiograptus geinitzianus is characteristic of this zone in Britain, Texas and Glenogle while in Australia it appears in the zone of G. teretiusculus. Parabrograptus tribrachiatus is a new record from this zone in Canada. Previously it was known only from the N. gracilis Zone of China.

SUMMARY

The type area of the Glenogle Formation is located in a five-mile strip, along the Kicking Horse River, near Golden, British Columbia and in particular in the railway-cutting near Glenogle Station and immediately south of the station on the south bank of the Kicking Horse River. Other scattered outcrops of graptolitic shales are found on the Trans-Canada Highway near the second highway bridge east of Golden; on the north bank of the Kicking Horse River just west of the second highway bridge; and near Tunnel 31.08 on the Canadian Pacific Railway.

Due to structural complications that took place during the Laramide Orogeny the incompetent Glenogle shale does not occur as a complete section but rather as scattered outcrops and partial sections which is in places sheared. Consequently the Glenogle area is not a good location for the type section. A much better location would have been at Windermere Creek where the section of Glenogle is complete, easily accessible and structurally uncomplicated.

Probably as a result of structural complexities, earlier workers collected rather indiscriminantly from the Glenogle area and lumped their collections. This resulted in confusion as to zonal content and geographic location of these collections. Careful collecting by the writer and Dr. D. E. Jackson, through an estimated fifteen hundred feet of Glenogle, has resulted in the recognition of all the zones present in the D. protobifidus-N. gracilis interval of Texas.

The graptolite assemblages collected at Glenogle belong to the Pacific Province and are correlated easily with Texas, Australia and the Yukon but less readily with Britain. Two minor modifications to the Texas sequence are made. One modification concerns the D. protobifidus Zone where the lack of diagnostic assemblages does not permit a zonal separation into the zones of D. bifidus and D. protobifidus and therefore the D. protobifidus zone is equated with the above

two zones of Texas. The second modification is the tentative recognition of the D. decoratus Zone which occurs in Australia in a position equivalent to the upper part of the P. etheridgei Zone of Texas.

Forty species belonging to twentyfour genera enabled the recognition of the zones of D. protobifidus, I. caduceus, P. etheridgei, ?D. decoratus and N. gracilis of Early and Middle Ordovician Age.

Four genera and nineteen species are recorded for the first time from the Glenogle Formation. Of the four genera, two were first recorded in China and two in Australia. Eleven of the species are Australian, two South American, three Chinese and two Swedish.

In the type area the boundary between the underlying McKay Formation and the Glenogle was observed just west of the second highway bridge east of Golden, B.C. This contact is gradational going from massive carbonates through interbedded shales and thin carbonates into the calcareous, silty black fissile shales of the Glenogle. The Wonah-Glenogle contact is covered and possibly faulted.

STRUCTURE

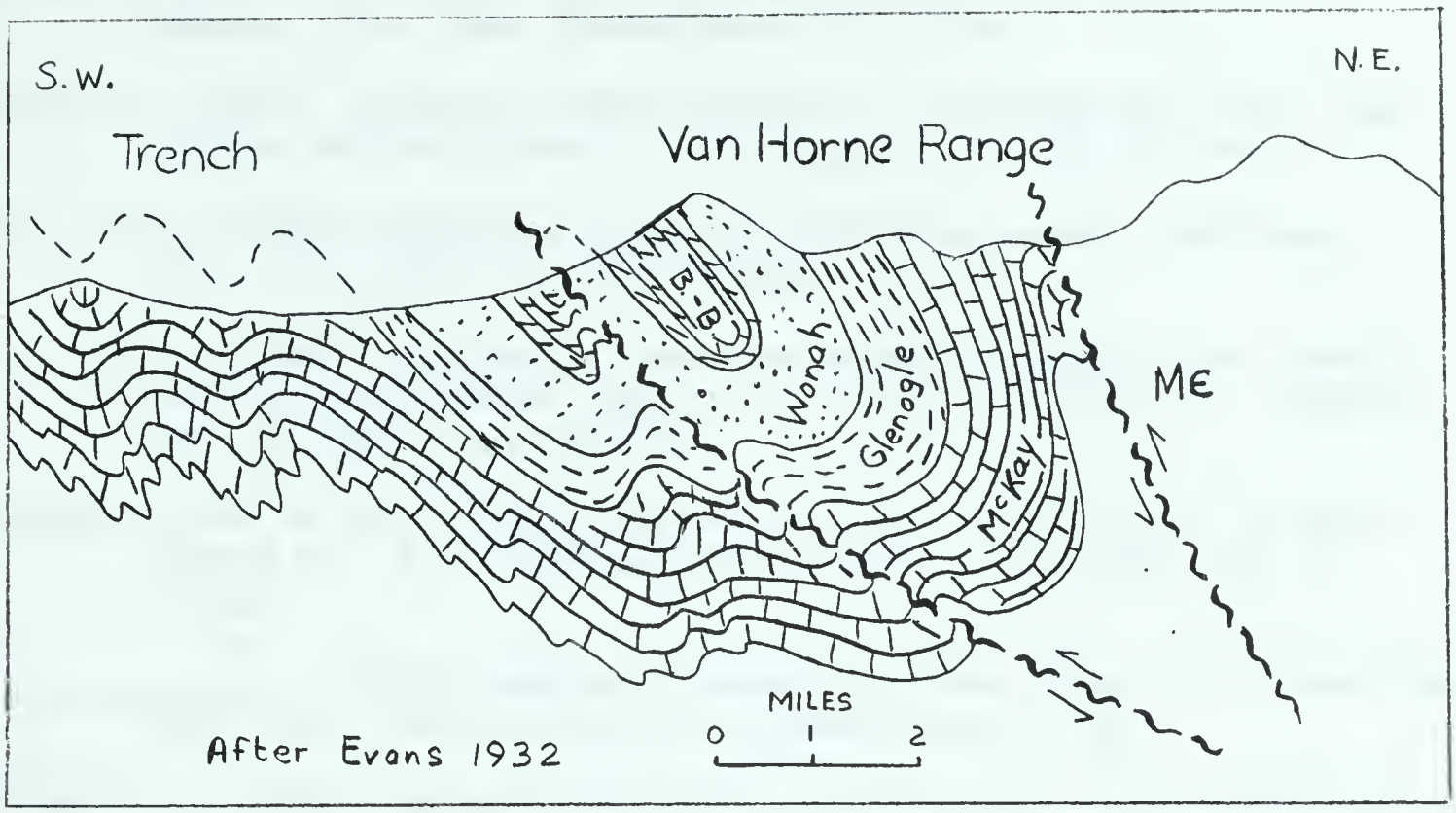

Fig. 10

The Kicking Horse River between Golden and Leanchoil cuts obliquely across the structures which are as follows: (1) An anticline overturned towards the southwest and exposing McKay, between Golden and a point 5 miles east of Golden; (2) The centre of a syncline overturned in the same direction exposes Glenogle and still younger strata, from 5 miles east of Golden to Glenogle Station (a distance of 3 miles); (3) From Glenogle Station to a point 11 miles southeast there is the overturned limb of this same syncline consisting of shales and limestones of McKay.

Figure 10 is a simplified diagram of the structural relationships and in detail the structure is quite complex. The incompetent Glenogle is structurally complex and as a result graptolite collections could be made only from those beds that were not severely cleaved.

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APPENDIX

Part A

1. Fauna of Sinclair Canyon (Walcott, 1924). Identified by Ruedemann.

    Trigonograptus ensiformis (J. Hall)
    Isograptus caduceus mut. nanus Rued.
    Phyllograptus anna var. ultimus Rued.
    Dichograptus octobrachiatus (J. Hall).
    Didymograptus cf. spinosus Rued.
    Glossograptus cf. hystrix Rued.
    Climacograptus cf. pungens Rued.
    Diplograptus dentatus Brongniart

2. Fauna of North Fork of Windermere Creek (Walker, 1926). Identified by Ruedemann.

    125 feet above the base:

        Didymograptus hirundo Salter
        Strophograptus sp.
        Retiograptus cf. tentaculatus (J. Hall)

    100 feet above the base:

        Didymograptus hirundo Salter
        D. sp. nov.
        Tetragraptus quadribrachiatus J. Hall
        Phyllograptus anna J. Hall
        Climacograptus pungens Rued.
        Glossograptus echinatus Rued.

    80 feet above base:

        Didymograptus walcottorum Rued.

3. Fauna of Tegart Mountain Section (Walker, 1926). Identified by Ruedemann. Thickness 450 feet.

    5 to 10 feet below top of the shale:

        Didymograptus filiformis Tulberg
        D. nicholsoni var. planus Elles and Wood
        Climacograptus pungens Rued.
        Glossograptus echinatus var. major Rued.
        Glyptograptus cf. dentatus Brongniart

    10 to 15 feet below top of shale:

        Tetragraptus quadribrachiatus (J. Hall)
        Retiograptus tentaculatus (J. Hall)
        Trigonograptus ensiformis (J. Hall)
        Glyptograptus dentatus (Brongniart)

40 to 50 feet below top of shale:

Didymograptus filiformis Tullberg
D. gibberulus Nicholson
Climacograptus pungens Rued.
Glossograptus echinatus Rued.

Base of shale:

Tetragraptus (bigsbyi) similis (J. Hall)
Didymograptus gibberulus Nicholson
D. walcottorum Rued.
D. cf. extensus (J. Hall)
Phyllograptus ilicifolius (J. Hall)

4. Fauna from Glenogle collected by Ami in 1891 and listed in Evans (1932) Collection identified by Ruedemann.

Thamnograptus capillaris (Emmons)
Azygograptus sp.
Corynoides gracilis mut. perungulatus Rued.
Nemagraptus gracilis (J. Hall)
N. exilis var. linearis Rued.
Didymograptus serratulus J. Hall
D. sagitticaulis Gurley
D. cf. subtennuis (J. Hall)
Dicellograptus sextans J. Hall
Diplograptus calcaratus var. incisus Lapworth
Glyptograptus euglyphus Lapworth
Climacograptus parvus J. Hall
C. eximius Rued.
Glossograptus ciliatus Emmons
Retiograptus geinitzianus J. Hall
Cryptograptus tricornis (Carruthers)

5. Fauna from section on west face of White Knight Mountain (Leech, 1954). Identified by T. E. Bolton of the Geological Survey of Canada.

454 Base of Wonah Formation.

447 Climacograptus sp. indet., Didymograptus spp., D. cf. spinosus Rued., Glossograptus spp., Lasiograptus sp. L. inutilis (J. Hall), Loganograptus logani pertenuis Rued., Phyllograptus cf. ilicifolius J. Hall.

359 Climacograptus sp., Lasiograptus echinatus Rued., L. echinatus major Rued., Tetragraptus sp., T. pendens Elles.

273 Diplograptus sp., Glossograptus cf. ciliatus Emmons, Loganograptus logani (J. Hall), L. cf. logani pertenuis Rued., Phyllograptus sp., P. cf. angustifolius J. Hall, Leptograptus flaccidus (J. Hall)

191-220 Diplograptus sp., Glossograptus horridus Rued., Isograptus walcottorum Rued., Phyllograptus cf. angustifolius J. Hall, Trigonograptus ensiformis (J. Hall).

153 Cardiograptus angustifolius Rued. Isograptus walcottorum, Rued.

118 Cardiograptus cf. folium Rued., Isograptus walcottorum Rued., Phyllograptus sp., P. ilicifolius J. Hall.

105 Isograptus walcottorum Rued.

97 Didymograptus nicholsoni var. planus Elles and Wood, Phyllograptus sp.

57 Didymograptus cf. nitidus (J. Hall), Isograptus walcottorum Rued.

6. Fauna from section on Moscow Creek Watershed (Leech, 1954). Identified by T. E. Bolton of G.S.C.

Feet above base:

1103 Base of Wonah Formation.

1102 Climacograptus sp., C. antiquus Lapworth, Didymograptus sp., Diplograptus gladius Rued., Glossograptus horridus Rued., G. echinatus major Rued., Thamnograptus sp.

1044 Climacograptus sp., Didymograptus sp., Glossograptus horridus Rued., Lasiograptus cf. inutilis (J. Hall).

941 Climacograptus cf. antiquus Lapworth, Didymograptus sp., D. cf. nicholsoni Lapworth, Diplograptus sp., Glossograptus horridus Rued., Lasiograptus echinatus Rued., L. echinatus major Rued., Trigonograptus ensiformis (J. Hall).

860-861 Climacograptus sp., Clonograptus cf. flexilis J. Hall, Glossograptus horridus Rued.

576 Cardiograptus folium Rued., Isograptus cf. caduceus (Salter), I. walcottorum Rued.

484 Didymograptus cf. euodus Lapworth, Isograptus walcottorum Rued.

433 Didymograptus cf. nicholsoni var. planus Elles and Wood, Isograptus walcottorum Rued., Phyllograptus angustifolius J. Hall.

7. Fauna from Pedley Pass (Henderson, 1954). Thickness 120 feet.

Feet below Wonah Formation:

12 Didymograptus nicholsoni var. planus Elles and Wood, Glossograptus horridus Rued., Trigonograptus ensiformis (J. Hall), Phyllograptus anna ultimus Rued., Didymograptus extensus Brongniart,. Glyptograptus dentatus, Isograptus furcula Rued., Lasiograptus (Hallograptus) inutilis (J. Hall).

18 Trigonograptus ensiformis (J. Hall), Glossograptus horridus Rued., G. echinatus Rued., Lasiograptus (Hallograptus) inutilis (J. Hall), Isograptus furcula Rued., I. walcottorum Rued.

44 Glossograptus horridus Rued., Glossograptus echinatus var. major Rued., Lasiograptus (Hallograptus) inutilis (J. Hall), Isograptus furcula Rued., Didymograptus patulus J. Hall, Didymograptus spinosus Rued.

65 Phyllograptus anna J. Hall, Glossograptus horridus Rued., G. echinatus var. major Rued., Lasiograptus (Hallograptus) inutilis (J. Hall), Climacograptus pungens Rued., Didymograptus patulus J. Hall, Isograptus furcula Rued.

APPENDIX

Part B

1. Section of Glenogle in Cable Creek. Incomplete. (Ref. DJ-2-62)

Ordovician:

Glenogle Formation

Lithology and fauna	Footage (top to bottom)
Shale, dark-grey weathering with paper fissility; very thin silty laminae, light grey, non-calcareous. *Glyptograptus* cf. *teretiusculus* (Hisinger), *Glossograptus hincksi* (Hopkinson) *Amplexograptus* sp., *Diplograptus* cf. *decoratus*, Harris and Thomas *Cryptograptus schaferi* (Lapworth)	0-92
Shale, light-grey weathering, very silty, grey.	92-214
Covered interval.	214-228
Shale, light-grey weathering, very silty, grey. *Glyptograptus* sp.	228-349
Covered interval.	349-361
Shale, as above.	361-667
Covered interval.	667-758
Shale, silty, dark-grey.	758-780
Covered interval.	780-864
Shale, buff-weathering, highly cleaved, dark-grey. Indet. biserial graptolites.	864-1167
Covered interval.	1167-1185
Shale, as above.	1185-1281
	1281 feet. Total

2. Section of Glenogle on the south bank of the Kicking Horse River and in the adjacent road-cutting on the south side of the Trans-Canada Highway. (Ref. ML-1-63, DJ-1-62).

Section is overturned to the south-west, striking N48°W, dipping 45°NE.

Ordovician:

Glenogle Formation

Lithology and fauna	Footage (top to bottom)
Contact with overlying Wonah not seen.	
Covered interval.	0-4
Shale, dark-grey, silty, calcareous, fissile, minor pyrite.	4-10
Shale, dark-grey, dark-grey weathering, very silty, calcareous, platy fissility.	10-50
Shale, black, dark-grey to black weathering, very silty with quartz stringers, slightly calcareous, fissile.	50-64
Shale, light grey-brown, olive-brown weathering, very calcareous, less silty than above, fissile.	64-104
Shale, dark-grey, dark-grey weathering, very calcareous, fissile. Glyptograptus cf. teretiusculus (Hisinger)	104-110
Shale, dark-grey, black weathering, silty laminae, calcareous, pyritic, fissile to platy.	110-130
Shale, black, dark-grey weathering, silty laminae, quartz veinlets, abundant pyrite stringers, platy to fissile.	130-170
Shale, as above. Dicellograptus sp., Glossograptus sp.	170-172
Shale, as above. Dicellograptus cf. sextans (J. Hall), Glossograptus hincksi mut. bispinatus Bulman, Glyptograptus cf. teretiusculus (Hisinger).	172-175
Shale, black, grey weathering, slightly calcareous, silty laminae, papery fissility. Dicellograptus cf. smithi Rued. Dicellograptus cf. sextans (J. Hall) Glossograptus cf. hincksi (Hopkinson)	175-179

Shale, dark-grey, buff weathering, slightly silty, calcareous, pyritic, fissile.	179-183
Shale, as above. Climacograptus sp., Dicranograptus sp., Dicellograptus cf. smithi Rued. Dicellograptus cf. sextans (J. Hall), Glossograptus hincksi mut. bispinatus Bulman, Glossograptus ciliatus var. douglasi (LapworthMS) Bulman, Retiograptus geinitzianus (J. Hall)	183-184
Shale, dark-grey, dark-grey weathering, silty laminae, slightly calcareous, pyritic, platy fissility. Climacograptus sp., Dicellograptus sp., Didymograptus sp.	184-186
Covered interval.	186-206
Shale, as above.	206-211
Shale, as above. Climacograptus sp.	211-213
Shale, dark-grey, dark-grey weathering, silty, calcareous, pyritic, cross-laminations, fissile. Climacograptus sp., Didymograptus aff. v-deflexus, Harris, Glossograptus cf. hincksi (Hopkinson), Glossograptus hincksi mut. bispinatus Bulman, Glyptograptus cf. teretiusculus (Hisinger), Retiograptus geinitzianus (J. Hall)	213-215
Shale, as above. Climacograptus, sp., Cryptograptus cf. schaferi (Lapworth), ?Didymograptus sp., Glossograptus cf. hincksi (Hopkinson), Glossograptus hincksi mut. bispinatus Bulman, Glyptograptus cf. teretiusculus (Hisinger), Glossograptus cf. whitfield (J. Hall), Retiograptus geinitzianus (J. Hall)	
Shale, black, dark-grey weathering, slightly silty, calcareous, pyrite stringers, fissile. Glossograptus hincksi (Hopkinson), Retiograptus geinitzianus (J. Hall)	218.5-220

3. Section at north end of Moberly Peak at the head of Moberly Creek. (Ref. ML-12-63)

Ordovician:

Glenogle Formation

Lithology	Footage (top to bottom)
Shale, dark-grey, grey weathering, extremely sheared. No fossils.	0-50
Covered interval.	50-170
Shale, dark-grey, black, contorted, cross-cutting quartz veinlets. No fossils.	170-600
Covered interval (approx.)	600-700

McKay Formation

4. Fauna collected from Loc. 1 (Ref. DJ-63, Spot check No. 1).

Diplograptus decoratus Harris and Thomas
Cryptograptus schaferi (Lapworth)
Glossograptus hincksi (Hopkinson)
?Didymograptus serratulus (J. Hall)

5. Fauna collected from Loc. 2 (Ref. DJ-63, Spot check No. 2).

Diplograptus cf. decoratus Harris and Thomas
Glyptograptus cf. teretiusculus (Hisinger)
Glossograptus cf. hincksi (Hopkinson)
Cryptograptus sp.

6. Fauna collected from Loc. 3 (Ref. DJ-63, Spot check No. 3)

Amplexograptus sp.
Cryptograptus schaferi (Lapworth)
Isograptus forcipiformis Rued.
Isograptus caduceus mut. nanus Rued.
Brachiograptus aff. etaformis Harris and Keble
Loganograptus sp.
Glossograptus cf. hincksi (Hopkinson)
Paraglossograptus etheridgei (Harris)
Pseudobryograptus incertus (Harris and Thomas)
Tetragraptus sp.
Trigonograptus ensiformis (J. Hall)

7. Fauna collected from Loc. 3a (Coll. Ref. ML-6-64)

Glossograptus echinatus Rued.
Tetragraptus sp.
Paraglossograptus etheridgei (Harris)

Loganograptus logani (J. Hall)
Glyptograptus sp.
Didymograptus cf. cognatus Harris

8. Fauna collected from Loc. 4 (Coll. Ref. ML-4-64)

Didymograptus cf. nitidus (J. Hall)
Isograptus caduceus cf. var. maximo-divergens Harris
Isograptus caduceus cf. var. maxima Harris
Isograptus caduceus cf. var. victoriae Harris
Tetragraptus bigsbyi var. latus Hsu

9. Fauna collected from Loc. 5 (Coll. Ref. DJ-63 Spot check No. 6)

?Didymograptus euodus Lapworth
?Didymograptus robustus Ekstrom
?Didymograptus cf. sagitticaulis Gurley
Glossograptus echinatus Rued.
Glossograptus echinatus var. major Rued.
cf. Glyptograptus euglyphus Lapworth
Paraglossograptus etheridgei (Harris)
Isograptus caduceus (Salter)
Isograptus forcipiformis Rued.
Tetragraptus bigsbyi var. latus Hsu
Trigonograptus ensiformis (J. Hall)
Trigonograptus ensiformis var. minor Rued.

10. Fauna collected from Loc. 6 (Coll. Ref. ML-10-64)

?Clonograptus
?Tetragraptus fruticosus (J. Hall)
?Didymograptus extensus (J. Hall)
Tetragraptus quadribrachiatus (J. Hall)
Tetragraptus cf. immaturus Hsu

PLATES 1-3

SELECTED FAUNA OF GRAPTOLITE ZONES

All figures are untouched with the exception of a-e on Plate 1; a-f, h-i, m and o on Plate 2; a, j, k, m and n on Plate 3. Figure h, Plate 3 is a line drawing and figure d on Plate 3 is upside down.

PLATE 1

Photo 1. Uppermost portion of Glenogle Formation (N. gracilis Zone) along Trans-Canada Highway, south of Glenogle station, looking east.

Photo 2. Railway-cutting, immediately west of Glenogle station, showing localities 1, 2, 3, 3a and the start of section DJ-2-62, looking northwest.

Zone of Didymograptus protobifidus

(All Figures X2)

Figures-

a. ?Clonograptus sp.

b. Tetragraptus cf. quadribrachiatus (J. Hall)

Zone of Isograptus caduceus

Figures-

c. Didymograptus cf. nitidus (J. Hall)

d. Isograptus caduceus cf. var. victoriae Harris

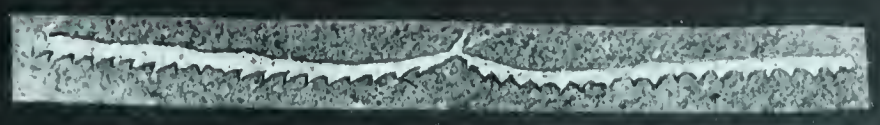
e. Isograptus caduceus cf. var. maximo-divergens Harris

1

2

a

b



c

d

e

PLATE 1.

PLATE 2

(All Figures X2)

Zone of *Paraglossograptus etheridgei*

Figures-

a. *Isograptus forcipiformis* Ruedemann

b. *Isograptus caduceus* mut. *nanus* Ruedemann

c. *Cryptograptus schaferi* (Lapworth)

d. ?*Amplexograptus* sp.

e. *Tetragraptus pendens* Elles

f. *Trigonograptus ensiformis* (J. Hall)

g. *Didymograptus* cf. *cognatus* Harris

h. *Paraglossograptus etheridgei* (Harris)

i. *Tetragraptus bigsbyi* var. *latus* (Hsu)

j. *Glossograptus echinatus* Ruedemann

k. *Glossograptus echinatus* var. *major* Ruedemann

l. *Loganograptus logani* (J. Hall)

m. *Brachiograptus* aff. *etaformis* Harris and Keble

n. *Pseudobryograptus incertus* (Harris and Thomas)

o. *Didymograptus* cf. *robustus* Ekstrom

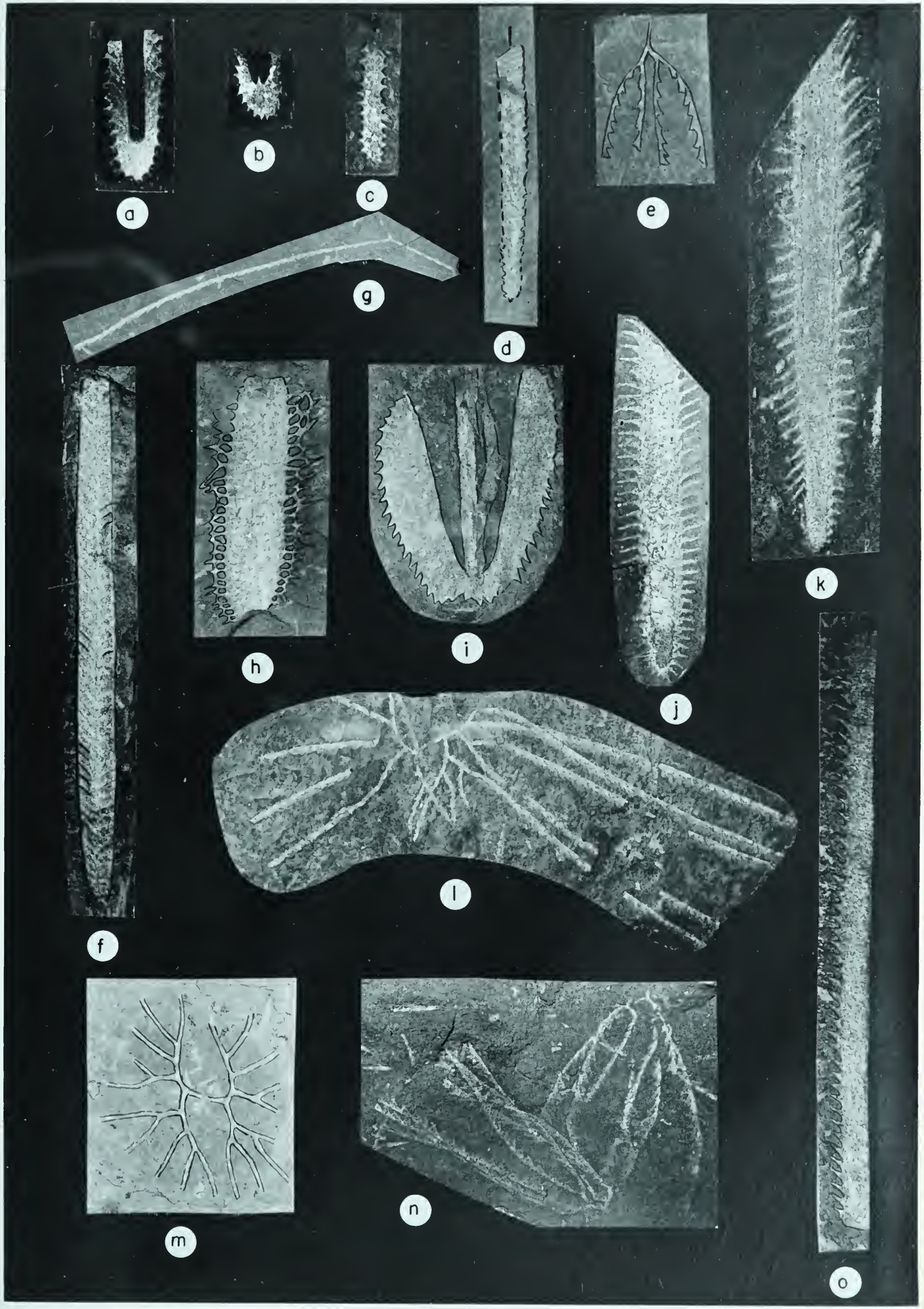


PLATE 2

PLATE 3

(All figures X2)

Zone of ?Diplograptus decoratus

Figures-

a. Diplograptus decoratus Harris and Thomas

b. Cryptograptus cf. schaferi (Lapworth)

c, d. Glossograptus hincksi (Hopkinson)

Zone of Glyptograptus cf. teretiusculus

e. Glyptograptus cf. teretiusculus (Hisinger)

Zone of Nemagraptus gracilis

f. Didymograptus aff. v-deflexus Harris

g. Glossograptus cf. whitfieldi (J. Hall)

h. Parabrograptus tribrachiatus Mu and Quiao

i. Retiograptus geinitzianus (J. Hall)

j. Dicellograptus cf. smithi Ruedemann

k. Dicellograptus cf. sextans (J. Hall)

l. ?Climacograptus sp.

m. Glyptograptus cf. teretiusculus (Hisinger)

n. Dicranograptus sp.

o. Glossograptus ciliatus var. douglasi (Lapworth MS) Bulman

p, q. Glossograptus hincksi mut. bispinatus Bulman

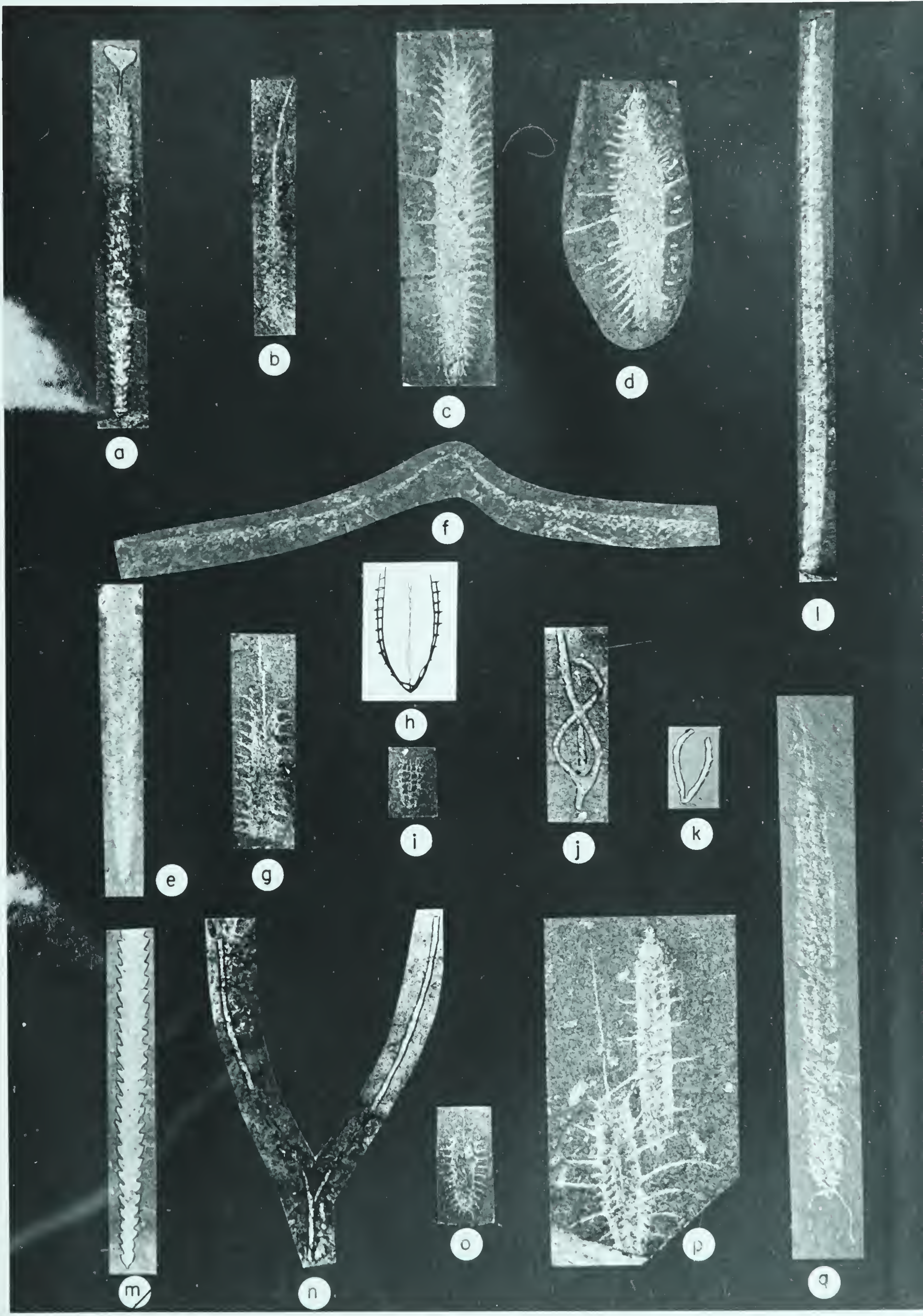
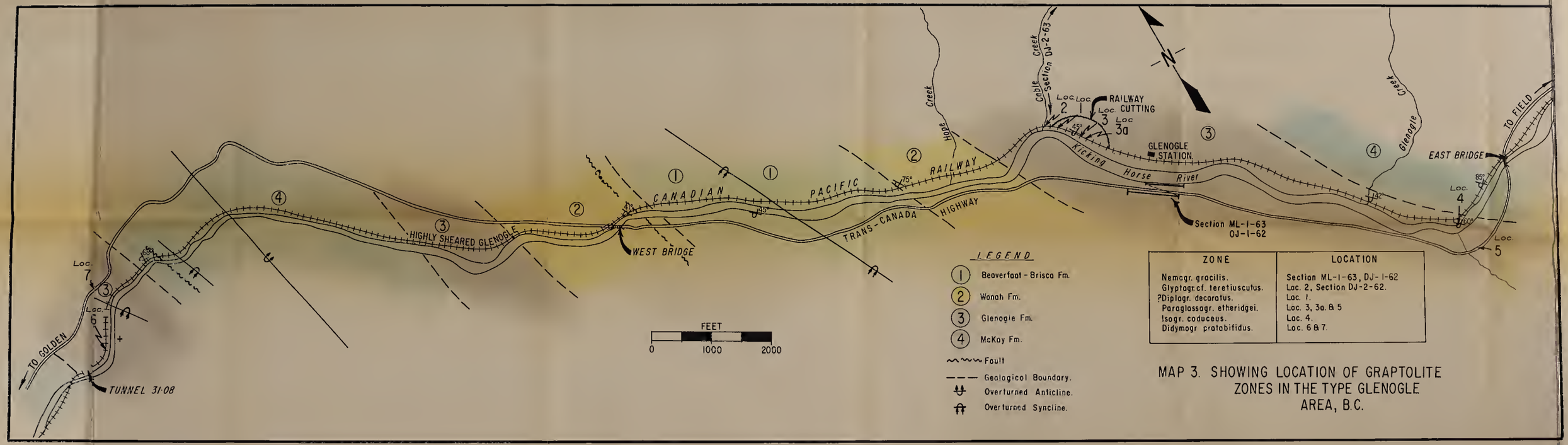


PLATE 3



ZONE	LOCATION
Nemagr. gracilis.	Section ML-1-63, DJ- 1-62
Glyptagr.cf. teretiuscutus.	Loc. 2, Section DJ-2-62.
?Diplagr. decoratus.	Loc. 1.
Paraglassagr. etheridgei.	Loc. 3, 3a. & 5
Isogr. coduceus.	Loc. 4.
Didymogr. pratobifidus.	Loc. 6 & 7.

MAP 3. SHOWING LOCATION OF GRAPTOLITE ZONES IN THE TYPE GLENOGLE AREA, B.C.

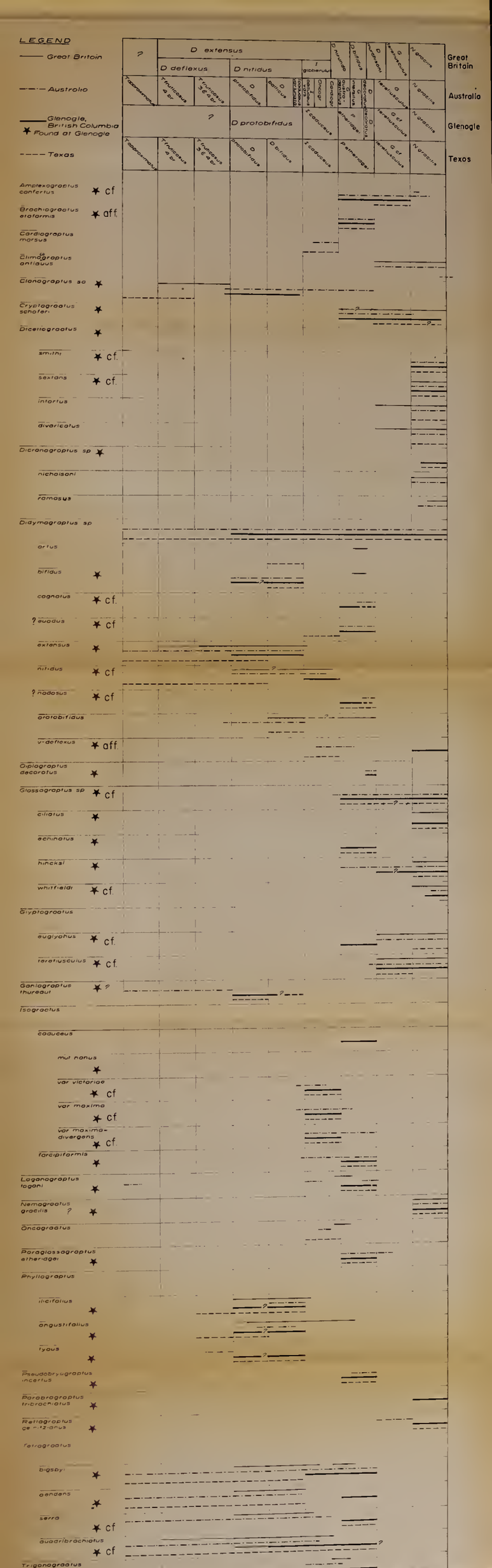


TABLE I. COMPARISON of STRATIGRAPHIC RANGES of LOWER & MIDDLE ORDOVICIAN GRAPTOLITES IN AUSTRALIA, GREAT BRITAIN, TEXAS AND GLENOGLE BRITISH COLUMBIA.